PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Semiconductors

Book S3 1985

Small-signal transistors

SMALL-SIGNAL TRANSISTORS

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

The contents of each series are listed on pages iv to viii.

The data handbooks contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:

T1 **Tubes for r.f. heating**

T2a **Transmitting tubes for communications, glass types**

T2b **Transmitting tubes for communications, ceramic types**

T3 **Klystrons, travelling-wave tubes, microwave diodes**

ET3 **Special Quality tubes, miscellaneous devices** (will not be reprinted)

T4 **Magnetrons for microwave heating**

T5 **Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications

T6 **Geiger-Müller tubes**

T7 **Gas-filled tubes**
Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories

T8 **Picture tubes and components**
Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display

T9 **Photo and electron multipliers**
Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates

T10 **Camera tubes and accessories**

T11 **Microwave semiconductors and components**

T12 **Vidicons and Newvicons**

T13 **Image intensifiers**

T14 **Infrared detectors**

T15 **Dry reed switches**

(T12–T15:) Data collations on these subjects are available now.
Data Handbooks will be published in 1985.

T16 **Monochrome tubes and deflection units**
Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S1	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
S2a	**Power diodes**
S2b	**Thyristors and triacs**
S3	**Small-signal transistors**
S4a	**Low-frequency power transistors and hybrid modules**
S4b	**High-voltage and switching power transistors**
S5	**Field-effect transistors**
S6	**R.F. power transistors and modules**
S7	**Surface mounted semiconductors**
S8	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.
S9	**Power MOS transistors**
S10	**Wideband transistors and wideband hybrid IC modules**
S11	**Microwave semiconductors** (to be published in 1985)
S12	**Surface acoustic wave devices**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXISTING SERIES

IC1 **Bipolar ICs for radio and audio equipment**

IC2 **Bipolar ICs for video equipment**

IC3 **ICs for digital systems in radio, audio and video equipment**

IC4 **Digital integrated circuits**
CMOS HE4000B family

IC5 **Digital integrated circuits – ECL**
ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs

IC6 **Professional analogue integrated circuits**

IC7 **Signetics bipolar memories**

IC8 **Signetics analogue circuits**

IC9 **Signetics TTL logic**

IC10 **Signetics Integrated Fuse Logic (IFL)**

IC11 **Microprocessors, microcomputers and peripheral circuitry**

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	
IC02N	**Video and associated systems** Bipolar, MOS	
IC03N	**Telephony equipment** Bipolar, MOS	
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family uncased integrated circuits** CMOS	(published 1984)
IC06N	**PC54/74HC/HCU/HCT logic families** HCMOS	
IC07N	**PC54/74HC/HCU/HCT uncased integrated circuits** HCMOS	
IC08N	**10K and 100K logic family** ECL	(published 1984)
IC09N	**Logic series** TTL	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Analogue - industrial**	
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom integrated fuse logic** IFL series 20/24/28	
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	
IC15N	**Logic series** FAST TTL	(published 1984)

Note

Books available in the new series are shown with their date of publication.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1 **Assemblies for industrial use**
PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs

C2 **Television tuners, video modulators, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Synchronous motors and gearboxes**

C7 **Variable capacitors**

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**
Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Variable resistors and test switches**

C13 **Fixed resistors**

C14 **Electrolytic and solid capacitors**

C15 **Ceramic capacitors***

C16 **Permanent magnet materials**

C17 **Stepping motors and associated electronics**

C18 **D.C. motors**

C19 **Piezoelectric ceramics**

C20 **Wire-wound components for TVs and monitors**

* Film capacitors are included in Data Handbook C22 which will be published in 1985. The September 1982 edition of C15 should be retained until C22 is issued.

SELECTION GUIDE

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW at	T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe}) at	I_C mA	f_T MHz typ.	F dB typ.	remarks	page
BC107			45				(125–500)			2		53
BC108	n-p-n	TO-18	20	100	300	25	(125–900)	2	> 300	2		53
BC109			20				(240–900)			1,2	low-noise type	53
BC140	n-p-n	TO-39	40	1000	3700	45*	40–250	100	> 50			67
BC141			60									67
BC146	n-p-n	SOT-42	20	50	50	45	80–550	0,2	150	2	hearing aids, watches	71
BC160	p-n-p	TO-39	40	1000	3700	45*	40–250	100	> 50			77
BC161			60									77
BC177			45				(75–260)			–		81
BC178	p-n-p	TO-18	25	100	300	25	(125–500)	2	150	–		81
BC179			20				(125–500)			1,2	low-noise type	81
BC200	p-n-p	SOT-42	20	50	50	45	50–400	0,2	90	2	hearing aids, watches	93
BC327			45									99
BC327A	p-n-p	TO-92 var.	60	500	800	25	100–600	100	100	–	driver and output stages	99
BC328			25									99
BC337			45									107
BC337A	n-p-n	TO-92 var.	60	500	800	25	100–600	100	200	–	driver and output stages	107
BC338			25									107
BC368	n-p-n	TO-92 var.	20	1000	800	25	85–375	500	60	–	class-B audio output stage	113
BC369	p-n-p	TO-92 var.	20	1000	800	25	85–375	500	60	–		121
BC375	n-p-n	TO-92 var.	20	1000	800	25	60–340	150	150	–	output stage	129
BC376	p-n-p	TO-92 var.	20	1000	800	25	60–340	150	150	–		131
BC546			65				(125–500)					133
BC547	n-p-n	TO-92 var.	45	100	500	25	(125–900)	2	300	2	driver stage audio amplifier	133
BC548			30				(125–900)					133
BC549	n-p-n	TO-92 var	30	100	500	25	(240–900)	2	300	1,4	low-noise stage	145
BC550			45									145

* T_{case}.

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	RATINGS I_C mA	RATINGS P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe})	at I_C mA	f_T MHz typ.	F dB typ.	remarks	page
BC556			65									157
BC557	p-n-p	TO-92 var.	45	100	500	25	(75–500)	2	150	2	driver stage audio amp.	157
BC558			30									157
BC559	p-n-p	TO-92 var.	30	100	500	25	(125–500)	2	150	1,2	low-noise types	163
BC560			45							1		163
BC635			45				40–250					171
BC637	n-p-n	TO-92 var.	60	1000	1000	25	40–160	150	130	–	driver stage	171
BC639			80				40–160					171
BC636			45				40–250					177
BC638	p-n-p	TO-92 var.	60	1000	1000	25	40–160	150	50	–	driver stage	177
BC640			80				40–160					177
BCY56	n-p-n	TO-18	45	100	300	25	100–450	2	85	1,5	low-noise types	183
BCY57			20				200–800		100			183
BCY58	n-p-n	TO-18	32	200	330	45	(125–700)	2	280	2	switching	187
BCY59			45									187
BCY70			40							2,0		197
BCY71	p-n-p	TO-18	45	200	350	25	> 100	10	450	0,8	low-noise types	197
BCY72			25							2,0		197
BCY78	p-n-p	TO-18	32	200	345	45	(125–700)	2	180	2	switching	217
BCY79			45									217
BCY87*										< 3	pre-stages of	225
BCY88*	p-n-p	TO-71	40	30	150	25	100–450	0,05	> 10	< 4	differential amplifier	225
BCY89*										< 4	long-tailed pairs	225
2N929	n-p-n	TO-18	45	30	300	25	100–350	10	80	2,5	low-level, low-noise	593
2N930							150–600			2,0	amplifier	593

* Dual transistors for differential amplifiers.

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe})	at I_C mA	f_T MHz typ.	F dB typ.	remarks	page
2N2483	n-p-n	TO-18	60	50*	360	25	<500	10	80	4	low-level, low noise amplifiers	637
2N2484							<800			3		637
2N4030	p-n-p	TO-39	60	1000	800	25	40–120	100	>100		large-signal, low-noise, low-power	675
2N4031			80				40–120		>100			675
2N4032			60				100–300		>150			675
2N4033			80				100–300		>150			675
2N4123	n-p-n	TO-92	30	200	350	25	(50–200)		>250	6	small-signal, low-power	679
2N4124			25				(120–480)		>300	5		679
2N4125	p-n-p	TO-92	30	200	350	25	(50–200)	2	>200	5		681
2N4126			25				(120–480)		>250	4		681
2N5400	p-n-p	TO-92	120	600	625	25	40–180	10	>100	8	high-voltage driver	683
2N5401			150				60–240	10	>100	8		683
2N5550	n-p-n	TO-92	140	600	625	25	60–250	10	>100	10	high-voltage driver	689
2N5551			160				60–250	10	>100	8		689

* I_{CM}.

Transistors for h.f. applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE}	at I_C mA	C_{re} pF typ.	f_T MHz typ.	F dB typ.	at f MHz	remarks	page
BF198	n-p-n	TO-92 var.	30	25	500	25	>10	15	0,20	400	3	35	gain-controlled TV i.f. amp.	233
BF199	n-p-n	TO-92 var.	25	25	500	25	>38	7	0,30	550			output video i.f. amp.	247
BF240	n-p-n	TO-92 var.	40	25	250	25	67–220	1	0,34	380	3,5	0,2	a.m. mixers and i.f. amp. in a.m./f.m. receivers	255
BF241							36–125			350				255
BF324	p-n-p	TO-92 var.	30	25	250	45	typ. 50	4	0,10*	450	3	100	r.f. stages in f.m. front-ends	259
BF370	n-p-n	TO-92 var.	15	100	500	25	>40	10	1,6	>500			large signal, i.f. amp.	265

* C_{br}

Transistors for h.f. applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} at mW	T_{amb} °C	CHARACTERISTICS h_{FE} at	I_C mA	C_{re} pF	f_T MHz	F at db	f MHz	remarks	page
BF420	n-p-n	TO-92 var.	300 ▲	50	830	25	> 50	25	1,0	> 60				269
BF421	p-n-p	TO-92 var.	300 ▲	50	830	25	> 50	25	1,1	> 60				275
BF422	n-p-n	TO-92 var.	250	50	830	25	> 50	25	1,0	> 60			class-B video output	269
BF423	p-n-p	TO-92 var.	250	50	830	25	> 50	25	1,1	> 60			class-B video output	275
BF450 BF451	p-n-p	TO-92 var.	40	25	250	45	62–200 30–90	1	0,35	325	2	100	mixer stages in a.m. receivers and i.f.stages for a.m./f.m.	281 281
BF483 BF485 BF487	n-p-n	TO-92 var.	250 300 350	100	830	25	> 50	25	1,4	> 70			video output	285 285 285
BF494	n-p-n	TO-92 var.	20	30	300	75	typ. 115	1	0,85	260	4	100	osc.,i.f. amp. in a.m./f.m. receivers	289
BF495	n-p-n	TO-92 var.	20	30	300	75	typ. 67	1	0,85	200	4	100	f.m.tuners, i.f.amp. in a.m./f.m.receivers and a.m.input stages car radios	297
BF496	n-p-n	TO-92 var.	20	20	300	75	> 12	2	0,80	550	2	100	gain-controlled v.h.f. amp.	305
BF926	p-n-p	TO-92 var.	20	25	250	45	> 30	1	0,5	350	5	200	mixer/osc. in v.h.f./u.h.f.	309
BF936	p-n-p	TO-92 var.	20	25	250	45	> 25	1	0,9	350	5	200	mixer/osc. in v.h.f./u.h.f.	311
BF939	p-n-p	TO-92 var.	25	20	225	55	> 16	2	0,7	750	2,5	200	gain-controlled v.h.f. amp.	313
BF967	p-n-p	SOT-37	30	20	160	55	> 15	3	0,45	900	4	800	gain-controlled v.h.f. amp.	317
BF970	p-n-p	SOT-37	35	30	160	55	> 25	3	0,475	900	4,7	800	self-osc. u.h.f. mixer stage	363
BF979	p-n-p	SOT-37	20	30*	140	55	> 20	10	0,65	1350	4,5	800	r.f. stages in u.h.f. tuners	325
BFR54	n-p-n	TO-92 var.	15	500*	500	25	> 40	10		> 500			freq. multipliers	329
BFY50 BFY51 BFY52	n-p-n	TO-39	35 30 20	1000	5000	50**	112 123 142	150		140 160 185			general purpose industrial and switching applications	349 349 349
BFY55	n-p-n	TO-39	35	1000	800	25	> 40	150		> 60			"	419
2N2297	n-p-n	TO-39	35	1000	800	25	40–120	150		> 60			"	625

For data on tetrode-MOS-FET types for v.h.f./u.h.f. applications see Handbook Field-effect transistors.

▲ V_{CER}.
* I_{CM}. ** T_{mb}.

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} at mW	T_{amb} °C	CHARACTERISTICS h_{FE} at	I_C mA	f_T MHz typ.	t_{off} at ns max.	I_C mA	remarks	page
BCY58	n-p-n	TO-18	32	200	330	45	80–1000	10	280	800	10		187
BCY59			45										187
BCY70			40							420	10		197
BCY71	p-n-p	TO-18	45	200	350	25	> 100	10	450			BCY71 is low-noise version	197
BCY72			25							420	10		197
BCY78	p-n-p	TO-18	32	200	345	45	80–1000	10	180	800	10	amplifying and switching	217
BCY79			45										217
BFT44	p-n-p	TO-39	300	500	5000	50**	50–150	10	70	125	500		337
BFT45			250										337
BFX34	n-p-n	TO-39	60	2000	5000	25**	40–150	2000	> 70	1200	5000	inverter and switching regulators	371
BFY50			35				typ. 112		140				349
BFY51	n-p-n	TO-39	30	1000	5000	50**	typ. 123	150	160	360	150	general purpose	349
BFY52			20				typ. 142		185				349
BSR50			45*										463
BSR51	n-p-n	TO-92 var.	60*	1000	800	25	>2000	500		1500	500	Darlington transistors	463
BSR52			80*										463
BSR60			45*										469
BSR61	p-n-p	TO-92 var.	60*	1000	800	25	>2000	500		1500	500	Darlington transistors	469
BSR62			80*										469
BSS38	n-p-n	TO-92 var.	100	100	500	25	> 20	4	> 60	1000	15	driver for numerical indicator tube	475
BSS50			45*										479
BSS51	n-p-n	TO-39	60*	1000	5000	25**	>2000	500		1000	500	Darlington transistors	479
BSS52			80*										479
BSS60			45*										487
BSS61	p-n-p	TO-39	60*	1000	5000	25**	>2000	500		1500	500	Darlington transistors	487
BSS62			80*										487
BSS68	p-n-p	TO-92 var.	100	100	500	25	> 30	25	> 50			general purpose	495

*V_{CER}. **T_{case}.

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW at	T_{amb} °C	CHARACTERISTICS h_{FE} at	I_C mA	f_T MHz typ.	t_{off} ns max. at	I_C mA	remarks	page
BSV15			40										499
BSV16	p-n-p	TO-39	60	1000	5000	25*	40–250	100	> 50	650	100	general purpose	499
BSV17			80										499
BSV64	n-p-n	TO-39	60	2000	5000	50*	> 40	2000	100	1200	5000	high-current saturation characteristics	509
BSW66A			100										515
BSW67A	n-p-n	TO-39	120	1000	5000	25*	> 30	500	130	900	500	general purpose	515
BSW68A			150										515
BSX19	n-p-n	TO-18	15	500**	360	25	20– 60	10	> 400	15		high-speed saturated switching and h.f. amplifier applications	523
BSX20							40–120		> 500	18			523
BSX45			40				40–250						545
BSX46	n-p-n	TO-39	60	1000	6250	25*	40–250	100	> 50	850	100	general purpose	545
BSX47			80				40–160						545
BSX59			45						450	60			557
BSX60	n-p-n	TO-39	30	1000	800	25	30– 90	500	475	70	500	very high speed core-driving purposes	557
BSX61			45						475	100			557
PH2222;R	n-p-n	TO-92 var.	30	800	625	25	> 75	10	> 250	285	150		573
PH2222A;R			40						> 300				573
PH2369	n-p-n	TO-92 var.	15	500**	500	25	40–120	10	> 500	18	10		577
PH2907;R	p-n-p	TO-92 var.	40	600	625	25	100–300	150	> 200	100	150		587
PH2907A;R			60										587
PH5415	p-n-p	TO-92 var.	200	1000	500	25	30–150	50	> 15			high-voltage switching	591
PH5416	p-n-p	TO-92 var.	300	1000	500	25	30–120	50	> 15				591
2N1613	n-p-n	TO-39	(50)	500**	800	25	40–120	150	> 60			d.c. and high-speed amplifiers	597
2N1711	n-p-n	TO-39	(50)	1000**	800	25	100–300	150	> 70				605
2N1893	n-p-n	TO-39	80	500	3000	25*	40–120	150	> 50				609
2N2219	n-p-n	TO-39	30	800	800	25	100–300	150	> 250	285	150	high-speed switching	613
2N2219A			40						> 300				613

* T_{case}. ** I_{CM}.

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} (V_{CER}) V	I_C mA	P_{tot} mW at	T_{amb} (T_{case}) °C	CHARACTERISTICS h_{FE} at	I_C mA	f_T MHz typ.	t_{off} ns max. at	I_C mA	remarks	page
2N2222	n-p-n	TO-18	30	800	500	25	100–300	150	250	285	150	high-speed switching	619
2N2222A			40						300				619
2N2368	n-p-n	TO-18	15	500*	360	25	20– 60	10	> 400	15	10	very high speed saturated switching	629
2N2369							40–120	10	> 500	18	10		629
2N2369A	n-p-n	TO-18	15	200	360	25	> 40	10	> 500	18	10	very high speed saturated switching	633
2N2904	p-n-p	TO-39	40	600	600	25	40–120	150	> 200	100	150	high-speed switching and driver applications	641
2N2904A			60										641
2N2905	p-n-p	TO-39	40	600	600	25	100–300	150	> 200	100	150	high-speed switching and driver applications	649
2N2905A			60										649
2N2906	p-n-p	TO-18	40	600	400	25	40–120	150	> 200	100	150	high-speed switching and driver applications	653
2N2906A			60										653
2N2907	p-n-p	TO-18	40	600	400	25	100–300	150	> 200	100	150	high-speed switching and driver applications	657
2N2907A			60										657
2N3019	n-p-n	TO-39	80	1000	800	25	100–300	150	> 100			amplifiers and medium-speed switching	661
2N3020							40–120	150	> 80				661
2N3053	n-p-n	TO-39	40	700	5000	(25)	50–250	150	> 100	–	–	medium-speed switching	665
2N3903	n-p-n	TO-92	40	200	350	25	50–150	10	> 250	225	10	high-speed saturated switching	607
2N3904							100–300	10	> 300	250	10		607
2N3905	p-n-p	TO-92	40	200	350	25	50–150	10	> 200	260	10		671
2N3906							100–300		> 250	300			671
2N4030	p-n-p	TO-39	60	1000	800	25	> 25	500	> 100	400	500	large signal, low-noise, low-power	675
2N4031			80				> 25	500	> 100				675
2N4032			60				> 70	500	> 150				675
2N4033			80				> 70	500	> 150				675
2N5400	p-n-p	TO-92	120	600	625	25	> 40	10	> 100			high-voltage switching	683
2N5401			150				> 60	10	> 100				683
2N5415	p-n-p	TO-39	200	1000	1000	50	30–150	50	> 15	850**	50	high-voltage general purpose amplifier applications	685
2N5416			300				30–120	50					685
2N5550	n-p-n	TO-92	140	60	625	25	> 60	10	> 100			high-voltage switching	689
2N5551			160				> 80	10	> 100				689

* I_{CM}. ** Typical value.

P-N-P-N DEVICES

Programmable unijunction transistors

type number	envelope	RATINGS V_{GA} V	I_A mA	I_{ARM} A	dI_A/dt A/µs	CHARACTERISTICS I_p µA max.	I_V µA min.	t_r ns max.	remarks	page
BRY39	TO-72	70	175	2,5	20	5	25	80	characteristics measured	435
BRY56	TO-92 var.	70	175	2,5	20	5	2	80	with R_G = 10 kΩ	459

Silicon controlled switches

type number	envelope	RATINGS V_{CBO} V	I_E mA	I_{ERM} A	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS V_{AK} V max.	I_H mA max	t_{on} µs max.	t_q µs max.	remarks	page
BR101	TO-72	50	175	2,5	275	25	1,4	1,0	–	–	characteristics measured	431
BRY39	TO-72	70	175	2,5	275	25	1,4	1,0	1,5	8	with R_G = 10 kΩ	441

Thyristor tetrode

type number	envelope	RATINGS I_T mA	I_{TRM} A	I_{TSM} A	dI_T/dt A/µs	CHARACTERISTICS at T_j = 25 °C V_{GKT} V min.	I_{GKT} µA min.	V_{GAT} V min.	I_{GAT} µA min.	t_q µs max.	remarks	page
BRY39	TO-72	250	2,5	3	20	0,5	1	–1	–100	3	V_{RRMmax} = 70 V	451

TYPE NUMBER SURVEY

In this alphanumeric list we present all small-signal transistors mentioned in this handbook.

type number	▲	envelope	V_{CEO} V	I_C mA	page	type number	▲	envelope	V_{CEO} V	I_C mA	page
BC107	n	TO-18	45	100	53	BC638	p	TO-92 var.	60	1000	177
BC108	n	TO-18	20	100	53	BC639	n	TO-92 var.	80	1000	171
BC109	n	TO-18	20	100	53	BC640	p	TO-92 var.	80	1000	177
BC140	n	TO-39	40	1000	67	BCY56	n	TO-18	45	100	183
BC141	n	TO-39	60	1000	67	BCY57	n	TO-18	20	100	183
BC146	n	SOT-42	20	50	71	BCY58	n	TO-18	32	200	187
BC160	p	TO-39	40	1000	77	BCY59	n	TO-18	45	200	187
BC161	p	TO-39	60	1000	77	BCY70	p	TO-18	40	200	197
BC177	p	TO-18	45	100	81	BCY71	p	TO-18	45	200	197
BC178	p	TO-18	25	100	81	BCY72	p	TO-18	25	200	197
BC179	p	TO-18	20	100	81	BCY78	p	TO-18	32	200	217
BC200	p	SOT-42	20	50	93	BCY79	p	TO-18	45	200	225
BC327	p	TO-92 var.	45	500	99	BCY87	n	TO-71	40	30	225
BC327A	p	TO-92 var.	60	500	99	BCY88	n	TO-71	40	30	225
BC328	p	TO-92 var.	25	500	99	BCY89	n	TO-71	40	30	225
BC337	n	TO-92 var.	45	500	107	BF198	n	TO-92 var.	30	25	233
BC337A	n	TO-92 var.	60	500	107	BF199	n	TO-92 var.	25	25	247
BC338	n	TO-92 var.	25	500	107	BF240	n	TO-92 var.	40	25	255
BC368	n	TO-92 var.	20	1000	113	BF241	n	TO-92 var.	40	25	255
BC369	p	TO-92 var.	20	1000	121	BF324	p	TO-92 var.	30	25	259
BC375	n	TO-92 var.	20	1000	129	BF370	n	TO-92 var.	15	100	265
BC376	p	TO-92 var.	20	1000	131	BF420	n	TO-92 var.	300**	50	269
BC546	n	TO-92 var.	65	100	133	BF421	p	TO-92 var.	300**	100	275
BC547	n	TO-92 var.	45	100	133	BF422	n	TO-92 var.	250	50	269
BC548	n	TO-92 var.	30	100	133	BF423	p	TO-92 var.	250	100	275
BC549	n	TO-92 var.	30	100	145	BF450	p	TO-92 var.	40	25	281
BC550	n	TO-92 var.	45	100	145	BF451	p	TO-92 var.	40	25	281
BC556	p	TO-92 var.	65	100	157	BF483	n	TO-92 var.	250	100	285
BC557	p	TO-92 var.	45	100	157	BF485	n	TO-92 var.	300	100	295
BC558	p	TO-92 var.	30	100	157	BF487	n	TO-92 var.	350	100	285
BC559	p	TO-92 var.	30	100	163	BF494	n	TO-92 var.	20	30	289
BC560	p	TO-92 var.	45	100	163	BF495	n	TO-92 var.	20	30	297
BC635	n	TO-92 var.	45	1000	171	BF496	n	TO-92 var.	20	20	305
BC636	p	TO-92 var.	45	1000	177	BF926	p	TO-92 var.	20	25	309
BC637	n	TO-92 var.	60	1000	171	BF936	p	TO-92 var.	20	25	311

* I_{CM}.
** V_{CER}.

▲ n = n-p-n; p = p-n-p.

type number	▲	envelope	V_{CEO} V	I_C mA	page	type number	▲	envelope	V_{CEO} V	I_C mA	page
BF939	p	TO-92 var.	25	20	313	BSX45	n	TO-39	40	1000	545
BF967	p	SOT-37	30	20	317	BSX46	n	TO-39	60	1000	545
BF970	p	SOT-37	35	30	323	BSX47	n	TO-39	80	1000	545
BF979	p	SOT-37	30	30*	325	BSX59	n	TO-39	45	1000	557
BFR54	n	TO-92 var.	15	500*	329	BSX60	n	TO-39	30	1000	557
BFT44	p	TO-39	300	500	337	BSX61	n	TO-39	45	1000	557
BFT45	p	TO-39	250	500	337	BSY95A	n	TO-18	15	100	569
BFX29	p	TO-39	60	600	345	PH2222;R	n	TO-92 var.	30	800	573
BFX30	p	TO-39	65	600	359	PH2222A	n	TO-92 var.	40	800	573
BFX34	n	TO-39	60	2000	371	PH2222AR	n	TO-92 var.	40	800	573
BFX84	n	TO-39	60	1000	377	PH2369	n	TO-92 var.	15	500*	577
BFX85	n	TO-39	60	1000	377	PH2907;R	p	TO-92 var.	40	600	587
BFX86	n	TO-39	35	1000	377	PH2907A	p	TO-92 var.	60	600	587
BFX87	p	TO-39	50	600	345	PH2907AR	p	TO-92 var.	60	600	587
BFX88	p	TO-39	40	600	345	PH5415	p	TO-92 var.	200	1000	591
BFY50	n	TO-39	35	1000	349	PH5416	p	TO-92 var.	300	1000	591
BFY51	n	TO-39	30	1000	349	2N929	n	TO-18	45	30	593
BFY52	n	TO-39	20	1000	349	2N930	n	TO-18	45	30	593
BFY55	n	TO-39	35	1000	419	2N1613	n	TO-39	50**	1000*	597
BR101	p[1]	TO-72	50	175	431	2N1711	n	TO-39	50**	1000	605
BRY39	p[1]	TO-72	70	175	435	2N1893	n	TO-39	80	500	609
BRY56	p[1]	TO-92 var.	70	175	459	2N2219	n	TO-39	30	800	613
BSR50	n	TO-92 var.	45**	1000	463	2N2219A	n	TO-39	40	800	613
BSR51	n	TO-92 var.	60**	1000	463	2N2222	n	TO-18	30	800	619
BSR52	n	TO-92 var.	80**	1000	463	2N2222A	n	TO-18	40	800	619
BSR60	p	TO-92 var.	45**	1000	469	2N2297	n	TO-39	35	1000	625
BSR61	p	TO-92 var.	60**	1000	469	2N2368	n	TO-18	15	500*	629
BSR62	p	TO-92 var.	80**	1000	469	2N2369	n	TO-18	15	500*	629
BSS38	n	TO-92 var.	100	100	475	2N2369A	n	TO-18	15	200	633
BSS50	n	TO-39	45**	1000	479	2N2483	n	TO-18	60	50*	637
BSS51	n	TO-39	60**	1000	479	2N2484	n	TO-18	60	50*	637
BSS52	n	TO-39	80**	1000	479	2N2904	p	TO-39	40	600	641
BSS60	p	TO-39	45**	1000	487	2N2904A	p	TO-39	60	600	641
BSS61	p	TO-39	60**	1000	487	2N2905	p	TO-39	40	600	649
BSS62	p	TO-39	80**	1000	487	2N2905A	p	TO-39	60	600	649
BSS68	p	TO-92 var.	100	100	495	2N2906	p	TO-18	40	600	653
BSV15	p	TO-39	40	1000	499	2N2906A	p	TO-18	60	600	653
BSV16	p	TO-39	60	1000	499	2N2907	p	TO-18	40	600	657
BSV17	p	TO-39	80	1000	499	2N2907A	p	TO-18	60	600	657
BSV64	n	TO-39	60	2000	509	2N3019	n	TO-39	80	1000	600
BSW66A	n	TO-39	100	1000	515	2N3020	n	TO-39	80	700	661
BSW67A	n	TO-39	120	1000	515	2N3053	n	TO-39	40	700	665
BSW68A	n	TO-39	150	1000	515	2N3903	n	TO-92	40	200	667
BSX19	n	TO-18	15	500*	523	2N3904	n	TO-92	40	200	667
BSX20	n	TO-18	15	500*	523	2N3905	p	TO-92	40	200	671

* I_{CM}.
** V_{CER}.

▲ n = n-p-n; p = p-n-p; p[1] = p-n-p-n.

type number	▲	envelope	V_{CEO} V	I_C mA	page
2N3906	p	TO-92	40	200	671
2N4030	p	TO-39	60	1000	675
2N4031	p	TO-39	80	1000	675
2N4032	p	TO-39	60	1000	675
2N4033	p	TO-39	80	1000	675
2N4123	n	TO-92	30	200	679
2N4124	n	TO-92	25	200	679
2N4125	p	TO-92	30	200	681
2N4126	p	TO-92	25	200	681
2N5400	p	TO-92	120	600	683
2N5401	p	TO-92	150	600	683
2N5415	p	TO-39	200	1000	685
2N5416	p	TO-39	300	1000	685
2N5550	n	TO-92	160	600	689
2N5551	n	TO-92	180	600	689

▲ n = n-p-n; p = p-n-p.

CONVERSION LIST

conventional to microminiature type

conventional type	microminiature type	conventional type	microminiature type	conventional type	microminiature type
BA243	BAT18	BC177B	BC857B	BC368	BC868
BA314	BAS17		BCW70	BC369	BC869
BA481	BAT17	BC178	BC858	BC546	BC846
BA482	BAT18		BCW29/30		BCV71/72
BAV19	BAS19	BC178A	BC858A	BC546A	BC846A
BAV20	BAS20		BCW29		BCV71
BAV21	BAS21	BC178B	BC858B	BC546B	BC846B
BAW62	BAS16		BCW30		BCV72
	BAV70	BC179	BC859	BC547	BC847
	BAV99		BCF29/30		BCW71/72/81
	BAW56	BC179A	BC859A	BC547A	BC847A
BB405	BBY31		BCF29		BCW71
BB809	BBY40	BC179B	BC859B	BC547B	BC847B
BC107	BC847		BCF30		BCW72
	BCW71/72	BC200/01	BC859B	BC547C	BC847C
BC107A	BC847A		BCF29		BCW81
	BCW71	BC200/02	BC859B/C	BC548	BC848
BC107B	BC847B		BCF29/30		BCW31-33
	BCW72	BC200/03	BC859C	BC548A	BC848A
BC108	BC848		BCF30		BCW31
	BCW31-33	BC327	BC807	BC548B	BC848B
BC108A	BC848A		BCX17		BCW32
	BCW31	BC327-16	BC807-16	BC548C	BC848C
BC108B	BC848B	BC327-25	BC807-25		BCW33
	BCW32	BC327-40	BC807-40	BC549	BC849
BC109	BC849	BC327A			BCF32/33
	BCF32/33	BC328	BC808	BC549B	BC849B
BC109B	BC849B		BCX18		BCF32
	BCF32	BC328-16	BC808-16	BC549C	BC849C
BC109C	BC849C	BC328-25	BC808-25		BCF33
	BCF33	BC328-40	BC808-40	BC550	BC850
BC146/01	BC849B	BC337	BC817		BCF81
	BCF32		BCX19	BC550B	BC850B
BC146/02	BC849B/C	BC337-16	BC817-16	BC550C	BC850C
	BCF32/33	BC337-25	BC817-25	BC556	BC856
BC146/03	BC849C	BC337-40	BC817-40		BCW89
	BCF33	BC338	BC818	BC556A	BC856A
BC177	BC857		BCX20		BCW89
	BCW69/70	BC338-16	BC818-16	BC556B	BC856B
BC177A	BC857A	BC338-25	BC818-25	BC557	BC857
	BCW69	BC338-40	BC818-40		BCW69/70

conventional type	microminiature type	conventional type	microminiature type	conventional type	microminiature type
BC557A	BC857A	BCY56	BC850B	BF241	
	BCW69		BCF70	BF324	BF824
BC557B	BC857B	BCY57	BC849	BF410A	BF510
	BCW70		BCF32/33	BF410B	BF511
BC557C	BC857C	BCY58	BC849	BF410C	BF512
BC558	BC858		BCW60 fam.	BF410D	BF513
	BCW29/30	BCY58-VII	BCW60A	BF419	BST40
BC558A	BC858A	BCY58-VIII	BC849B	BF420	BF620
	BCW29		BCW60B		BF820
BC558B	BC858B	BCY58-IX	BC849B	BF421	BF621
	BCW30		BCW60C		BF821
BC558C	BC858C	BCY58-X	BC849C	BF422	BF622
BC559	BC859		BCW60D		BF822
	BCF29/30	BCY59	BC850	BF423	BF623
BC559A	BC859A		BCX70 fam.		BF823
	BCF29	BCY59-VII	BCX70G	BF450	BF550
BC559B	BC859B	BCY59-VIII	BC850B	BF451	
	BCF30		BCX70H	BF457	BST40
BC559C	BC859C	BCY59-IX	BC850B	BF458	BST40
BC560	BC860		BCX70J	BF459	BST39
	BCF70	BCY59-X	BC850C	BF469	BF622
BC560A	BC860A		BCX70K	BF470	BF623
BC560B	BC860B	BCY70	BC860	BF471	BF620
	BCF70		BCF70	BF472	BF621
BC560C	BC860C	BCY71	BC860	BF494	BFS19
BC635	BCX54		BCF70	BF494B	BFS19
BC635-6	BCX54-6	BCY72	BC859	BF494C	BFS19
BC635-10	BCX54-10		BCF29/30	BF495	BFS18
BC635-16	BCX54-16	BCY78	BC859	BF495C	BFS18
BC636	BCX51		BCW61 fam.	BF495D	BFS18
BC636-6	BCX51-6	BCY78-VII	BC859A	BF606A	BF660
BC636-10	BCX51-10		BCW61A	BF819	BST40
BC636-16	BCX51-16	BCY78-VIII	BC859A/B	BF857	BST40
BC637	BCX55		BCW61B	BF858	BST40
BC637-6	BCX55-6	BCY78-IX	BC859B	BF859	BST39
BC637-10	BCX55-10		BCW61C	BF869	BF622
BC637-16	BCX55-16	BCY78-X	BC859C	BF870	BF623
BC638	BCX52		BCW61D	BF871	BF620
BC638-6	BCX52-6	BCY79	BC860	BF872	BF621
BC638-10	BCX52-10		BCX71 fam.	BF926	BF660
BC638-16	BCX52-16	BCY79-VII	BC860A	BF936	BF536
BC639	BCX56		BCX71G	BF939	
BC639-6	BCX56-6	BCY79-VIII	BC860A/B	BF960	BF989
BC639-10	BCX56-10		BCX71H	BF964	BF994
BC639-16	BCX56-16	BCY79-IX	BC860B	BF966	BF996
BC640	BCX53		BCX71J	BF967	BF767
BC640-6	BCX53-6	BF198		BF970	BF569
BC640-10	BCX53-10	BF199	BFS20	BF979	BF579
BC640-16	BCX53-16	BF240		BF980	BF990

conventional type	microminiature type	conventional type	microminiature type	conventional type	microminiature type
BF981	BF991	BSS68	BSS63	2N2368	BSV52
BF982	BF992	BSV15	BSR30/31	2N2369	BSV52
BFQ23	BFT93	BSV15-6	BSR30	2N2369A	BSV52
BFQ24	BFT93	BSV15-10	BSR30/31	2N2483	BC850B
BFQ34	BFQ18A	BSV15-16	BSR31	2N2484	BC850B/C
BFQ51	BFT92	BSV16	BSR30/31	2N2894A	BSR12
BFQ52	BFT92	BSV16-6	BSR30	2N2905	BSR15
BFR54	BSV52	BSV16-10	BSR30/31	2N2905A	BSR16
BFR90	BFR92A	BSV16-16	BSR31	2N2907	BSR15
BFR91	BFR93A	BSV17	BSR32/33	2N2907A	BSR16
BFR96	BFQ19	BSV17-6	BSR32	2N3019	BSR43
BFT24	BFT25	BSV17-10	BSR32/33	2N3020	BSR42
BFT44	BST16	BSX19	BSV52	2N3053	BSR40/41
BFT45	BST15/16	BSX20	BSV52	2N3903	BSR17
BFW11	BFR30	BSX45	BSR40/41	2N3904	BSR17A
BFW12	BFR31	BSX45-6	BSR40	2N3905	BSR18
BFW13	BFT46	BSX45-10	BSR40/41	2N3906	BSR18A
BFW16A	BFQ17	BSX45-16	BSR41	2N4030	BSR30
BFW30	BFR53	BSX46	BSR40/41	2N4031	BSR31
BFW92	BFS17	BSX46-6	BSR40	2N4032	BSR32
BFW93	BFR53	BSX46-10	BSR40/41	2N4033	BSR33
BFX29	BSR16	BSX46-16	BSR41	2N4123	BSR17
BFX30	BSR16	BSX47	BSR42/43	2B4124	BSR18
BFX84	BSR40	BSX47-6	BSR42	2N4856	BSR56
BFX85	BSR41	BSX47-10	BSR42/43	2N4857	BSR57
BFX86	BSR41	BSY95A	BSV52	2N4858	BSR58
BFX87	BSR16	BZX55	BZX84	2N5415	BST15
BFX88	BSR15	BZX79	BZX84	2N5416	BST16
BFY50	BSR40	BZV85	BZV49	BD135	BCX54
BFY51	BSR40	PH2222	BSR13	BD135-6	BCX54-6
BFY52	BSR40	PH2222A	BSR14	BD135-10	BCX54-10
BFY55	BSR40	PH2369	BSV52	BD135-16	BCX54-16
BFY90	BFS17	PH2907	BSR15	BD136	BCX51
BR101	BRY62	PH2907A	BSR16	BD136-6	BCX51-6
BRY39	BRY62	1N4148	BAS16	BD136-10	BCX51-10
BRY56	BRY61		BAV70	BD136-16	BCX51-16
BSR50	BST50		BAV99	BD137	BCX55
BSR51	BST51		BAW56	BD137-6	BCX55-6
BSR52	BST52	2N929	BC850	BD137-10	BCX55-10
BSR60	BST60	2N930	BC850	BD137-16	BCX55-16
BSR61	BST61		BCF81	BD138	BCX52
BSR62	BST62	2N1613	BSR40	BD138-6	BCX52-6
BSS38	BSS64	2N1711	BSR41	BD138-10	BCX52-10
BSS50	BST50	2N1893	BSR42	BD138-16	BCX52-16
BSS51	BST51	2N2219	BSR13	BD139	BCX56
BSS52	BST52	2N2219A	BSR14	BD139-6	BCX56-6
BSS60	BST60	2N2222	BSR13	BD139-10	BCX56-10
BSS61	BST61	2N2222A	BSR14	BD139-16	BCX56-16
BSS62	BST62	2N2297	BSR40	BD140	BCX53

conventional type	microminiature type	conventional type	microminiature type	conventional type	microminiature type
BD140-6	BCX53-6	BDW57	BCX55	BDX43	BST51
BD140-10	BCX53-10	BDW58	BCX52	BDX44	BST52
BD140-16	BCX53-16	BDW59	BCX56	BDX45	BST60
BDW55	BCX54	BDW60	BCX53	BDX46	BST61
BDW56	BCX51	BDX42	BST50	BDX47	BST61

GENERAL

Type designation
Rating systems
Letter symbols
SOAR curves
s-parameters

PRO ELECTRON TYPE DESIGNATION CODE FOR SEMICONDUCTOR DEVICES

This type designation code applies to discrete semiconductor devices — as opposed to integrated circuits —, multiples of such devices and semiconductor chips.

"Although not all type numbers accord with the Pro Electron system, the following explanation is given for the ones that do."

A basic type number consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

FIRST LETTER

The first letter gives information about the material used for the active part of the devices.

A. GERMANIUM or other material with band gap of 0,6 to 1,0 eV.
B. SILICON or other material with band gap of 1,0 to 1,3 eV.
C. GALLIUM-ARSENIDE or other material with band gap of 1,3 eV or more.
R. COMPOUND MATERIALS (e.g. Cadmium-Sulphide).

SECOND LETTER

The second letter indicates the function for which the device is primarily designed.

A. DIODE; signal, low power
B. DIODE; variable capacitance
C. TRANSISTOR; low power, audio frequency ($R_{th\ j\text{-}mb} > 15$ °C/W)
D. TRANSISTOR; power, audio frequency ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ($R_{th\ j\text{-}mb} > 15$ °C/W)
G. MULTIPLE OF DISSIMILAR DEVICES – MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
N. PHOTO-COUPLER
P. RADIATION DETECTOR; e.g. high sensitivity phototransistor
Q. RADIATION GENERATOR; e.g. light-emitting diode (LED)
R. CONTROL AND SWITCHING DEVICE; e.g. thyristor, low power ($R_{th\ j\text{-}mb} > 15$ °C/W)
S. TRANSISTOR; low power, switching ($R_{th\ j\text{-}mb} > 15$ °C/W)
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
U. TRANSISTOR; power, switching ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
X. DIODE: multiplier, e.g. varactor, step recovery
Y. DIODE; rectifying, booster
Z. DIODE; voltage reference or regulator (transient suppressor diode, with third letter W)

SERIAL NUMBER

Three figures, running from 100 to 999, for devices primarily intended for consumer equipment.*
One letter (Z, Y, X, etc.) and two figures, running from 10 to 99, for devices primarily intended for industrial/professional equipment.*
This letter has no fixed meaning except W, which is used for transient suppressor diodes.

VERSION LETTER

It indicates a minor variant of the basic type either electrically or mechanically. The letter never has a fixed meaning, except letter R, indicating reverse voltage, e.g. collector to case or anode to stud.

SUFFIX

Sub-classification can be used for devices supplied in a wide range of variants called associated types. Following sub-coding suffixes are in use.

1. VOLTAGE REFERENCE and VOLTAGE REGULATOR DIODES: *ONE LETTER and ONE NUMBER*
   The LETTER indicates the nominal tolerance of the Zener (regulation, working or reference) voltage
   A. 1% (according to IEC 63: series E96)
   B. 2% (according to IEC 63: series E48)
   C. 5% (according to IEC 63: series E24)
   D. 10% (according to IEC 63: series E12)
   E. 20% (according to IEC 63: series E6)
   The number denotes the typical operating (Zener) voltage related to the nominal current rating for the whole range.
   The letter 'V' is used instead of the decimal point.

2. TRANSIENT SUPPRESSOR DIODES: *ONE NUMBER*
   The NUMBER indicates the maximum recommended continuous reversed (stand-off) voltage V_R. The letter 'V' is used as above.

3. CONVENTIONAL and CONTROLLED AVALANCHE RECTIFIER DIODES and THYRISTORS: *ONE NUMBER*
   The NUMBER indicates the rated maximum repetitive peak reverse voltage (V_{RRM}) or the rated repetitive peak off-state voltage (V_{DRM}), whichever is the lower. Reversed polarity is indicated by letter R, immediately after the number.

4. RADIATION DETECTORS: *ONE NUMBER*, preceded by a hyphen (–)
   The NUMBER indicates the depletion layer in µm. The resolution is indicated by a version LETTER.

5. ARRAY OF RADIATION DETECTORS and GENERATORS: *ONE NUMBER*, preceded by a stroke (/).
   The NUMBER indicates how many basic devices are assembled into the array.

* When these serial numbers are exhausted the serial number for consumer types may be extended to four figures, and that for industrial types to three figures.

RATING SYSTEMS

The rating systems described are those recommended by the International Electrotechnical Commission (IEC) in its Publication 134.

DEFINITIONS OF TERMS USED

Electronic device. An electronic tube or valve, transistor or other semiconductor device.

Note
This definition excludes inductors, capacitors, resistors and similar components.

Characteristic. A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

Bogey electronic device. An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics which are directly related to the application.

Rating. A value which establishes either a limiting capability or a limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms.

Note
Limiting conditions may be either maxima or minima.

Rating system. The set of principles upon which ratings are established and which determine their interpretation.

Note
The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

ABSOLUTE MAXIMUM RATING SYSTEM

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

DESIGN MAXIMUM RATING SYSTEM

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout life, no design maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

DESIGN CENTRE RATING SYSTEM

Design centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

I, i = current
V, v = voltage
P, p = power.

Lower-case basic letters shall be used for the representation of instantaneous values which vary with time.
In all other instances upper-case basic letters shall be used.

Subscripts

A, a	Anode terminal
(AV), (av)	Average value
B, b	Base terminal, for MOS devices: Substrate
(BR)	Breakdown
C, c	Collector terminal
D, d	Drain terminal
E, e	Emitter terminal
F, f	Forward
G, g	Gate terminal
K, k	Cathode terminal
M, m	Peak value
O, o	As third subscript: The terminal not mentioned is open circuited
R, r	As first subscript: Reverse. As second subscript: Repetitive. As third subscript: With a specified resistance between the terminal not mentioned and the reference terminal.
(RMS), (rms)	R.M.S. value
S, s	As first or second subscript: Source terminal (for FETS only) As second subscript: Non-repetitive (not for FETS) As third subscript: Short circuit between the terminal not mentioned and the reference terminal
X, x	Specified circuit
Z, z	Replaces R to indicate the actual working voltage, current or power of voltage reference and voltage regulator diodes.

Note: No additional subscript is used for d.c. values.

Upper-case subscripts shall be used for the indication of:

a) continuous (d.c.) values (without signal)

Example I_B

b) instantaneous total values

Example i_B

c) average total values

Example $I_{B(AV)}$

d) peak total values

Example I_{BM}

e) root-mean-square total values

Example $I_{B(RMS)}$

Lower-case subscripts shall be used for the indication of values applying to the varying component alone :

a) instantaneous values

Example i_b

b) root-mean-square values

Example $I_{b(rms)}$

c) peak values

Example I_{bm}

d) average values

Example $I_{b(av)}$

Note : If more than one subscript is used, subscript for which both styles exist shall either be all upper-case or all lower-case.

Additional rules for subscripts

Subscripts for currents

Transistors : If it is necessary to indicate the terminal carrying the current, this should be done by the first subscript (conventional current flow from the external circuit into the terminal is positive).

Examples : I_B, i_B, i_b, I_{bm}

Diodes : To indicate a forward current (conventional current flow into the anode terminal) the subscript F or f should be used; for a reverse current (conventional current flow out of the anode terminal) the subscript R or r should be used.

Examples : I_F, I_R, i_F, $I_{f(rms)}$

Subscripts for voltages

Transistors: If it is necessary to indicate the points between which a voltage is measured, this should be done by the first two subscripts. The first subscript indicates the terminal at which the voltage is measured and the second the reference terminal or the circuit node. Where there is no possibility of confusion, the second subscript may be omitted.

Examples: V_{BE}, v_{BE}, v_{be}, V_{bem}

Diodes: To indicate a forward voltage (anode positive with respect to cathode), the subscript F or f should be used; for a reverse voltage (anode negative with respect to cathode) the subscript R or r should be used.

Examples: V_F, V_R, v_F, V_{rm}

Subscripts for supply voltages or supply currents

Supply voltages or supply currents shall be indicated by repeating the appropriate terminal subscript.

Examples: V_{CC}, I_{EE}

Note: If it is necessary to indicate a reference terminal, this should be done by a third subscript

Example : V_{CCE}

Subscripts for devices having more than one terminal of the same kind

If a device has more than one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal followed by a number; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{B2} = continuous (d.c.) current flowing into the second base terminal

$V_{B2\text{-}E}$ = continuous (d.c.) voltage between the terminals of second base and emitter

Subscripts for multiple devices

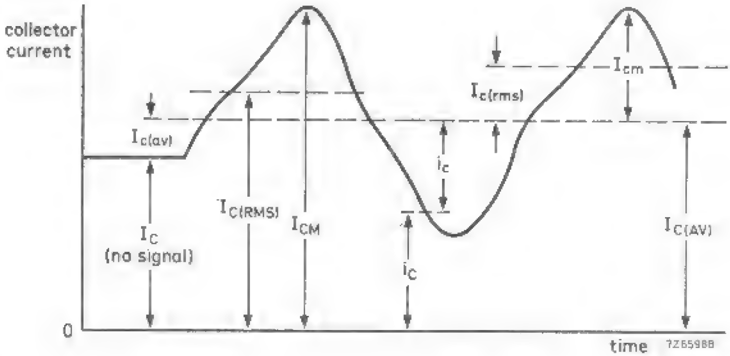
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{2C} = continuous (d.c.) current flowing into the collector terminal of the second unit

$V_{1C\text{-}2C}$ = continuous (d.c.) voltage between the collector terminals of the first and the second unit.

Application of the rules

The figure below represents a transistor collector current as a function of time. It consists of a continuous (d.c.) current and a varying component.



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

For the purpose of this Publication, the term "electrical parameter" applies to four-pole matrix parameters, elements of electrical equivalent circuits, electrical impedances and admittances, inductances and capacitances.

Basic letters

The following is a list of the most important basic letters used for electrical parameters of semiconductor devices.

B, b = susceptance; imaginary part of an admittance

C = capacitance

G, g = conductance; real part of an admittance

H, h = hybrid parameter

L = inductance

R, r = resistance; real part of an impedance

X, x = reactance; imaginary part of an impedance

Y, y = admittance;

Z, z = impedance;

Upper-case letters shall be used for the representation of:

a) electrical parameters of external circuits and of circuits in which the device forms only a part;

b) all inductances and capacitances.

Lower-case letters shall be used for the representation of electrical parameters inherent in the device (with the exception of inductances and capacitances).

Subscripts

General subscripts

The following is a list of the most important general subscripts used for electrical parameters of semiconductor devices:

F, f = forward; forward transfer
I, i (or 1) = input
L, l = load
O, o (or 2) = output
R, r = reverse; reverse transfer
S, s = source

Examples: Z_S, h_f, h_F

The upper-case variant of a subscript shall be used for the designation of static (d.c.) values.

Examples : h_{FE} = static value of forward current transfer ratio in common-emitter configuration (d.c. current gain)

R_E = d.c. value of the external emitter resistance.

Note: The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, i.e. the quotient of the appropriate electrical quantities at the operating point.

The lower-case variant of a subscript shall be used for the designation of small-signal values.

Examples: h_{fe} = small-signal value of the short-circuit forward current transfer ratio in common-emitter configuration

$Z_e = R_e + jX_e$ = small-signal value of the external impedance

Note: If more than one subscript is used, subscripts for which both styles exist shall either be all upper-case or all lower-case

Examples: h_{FE}, y_{RE}, h_{fe}

Subscripts for four-pole matrix parameters

The first letter subscript (or double numeric subscript) indicates input, output, forward transfer or reverse transfer

Examples: h_i (or h_{11})
h_o (or h_{22})
h_f (or h_{21})
h_r (or h_{12})

A further subscript is used for the identification of the circuit configuration. When no confusion is possible, this further subscript may be omitted.

Examples: h_{fe} (or h_{21e}), h_{FE} (or h_{21E})

Distinction between real and imaginary parts

If it is necessary to distinguish between real and imaginary parts of electrical parameters, no additional subscripts should be used. If basic symbols for the real and imaginary parts exist, these may be used.

Examples: $Z_i = R_i + jX_i$
$y_{fe} = g_{fe} + jb_{fe}$

If such symbols do not exist or if they are not suitable, the following notation shall be used:

Examples: Re (h_{ib}) etc. for the real part of h_{ib}
Im (h_{ib}) etc. for the imaginary part of h_{ib}

TRANSISTOR SAFE OPERATING AREA

If a power transistor is to give reliable service, four operating limits must be observed:

- Maximum collector current.
- Maximum collector-emitter voltage.
- Maximum power dissipation.
- Second breakdown limit.

These limits are all specified in the data sheets; the purpose here is to enable designers to make the best use of that information.

Collector current

Maximum collector current I_{Cmax} is specified in the data sheets for d.c. operation. For pulsed operation a higher collector current I_{Cmax} is permitted, for a defined maximum pulse length (usually 10 ms) and duty factor (usually 0,01).

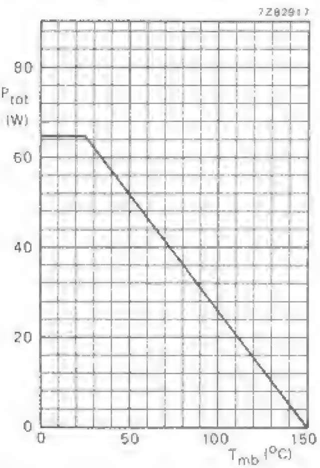
For power switching transistors I_{Csat} is given; this is the value at which switching times and saturation voltage is measured.

Collector-emitter voltage

Maximum collector-emitter voltage V_{CEO} is also specified in the data sheets, but no extension is allowed for pulsed operation. In the case of power transistors specifically designed for switching inductive loads some extension may be allowed, but then only under specified conditions of collector current, base-emitter voltage and emitter-base resistance as stated in the relevant data sheets.

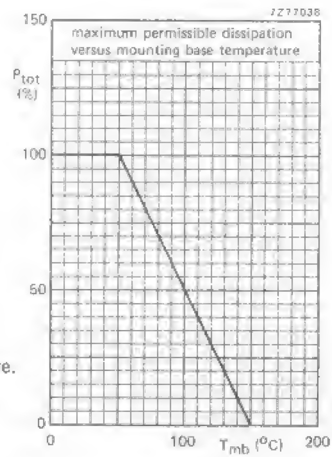
Power dissipation

Maximum power dissipation $P_{tot\,max}$ is specified in the data sheets for a given mounting base temperature. This is usually 25 °C but may be any, much higher temperature. $P_{tot\,max}$ applies up to the stated temperature; above it derating must be applied. A power derating curve of the form shown in Fig. 1a and 1b given in the data sheets. With it, maximum allowable power dissipation can be calculated for any mounting base temperature up to $T_{j\,max}$.



(a)

Fig. 1 Power derating curve.



(b)

Total power dissipation is given by

$$P_{tot} = I_C V_{CE} + I_B V_{BE}.$$

The second term can usually be disregarded, so $P_{tot} \approx I_C V_{CE}$.
Heat dissipated in the collector-base junction flows through the thermal resistance between junction and mounting base, see Fig. 2.

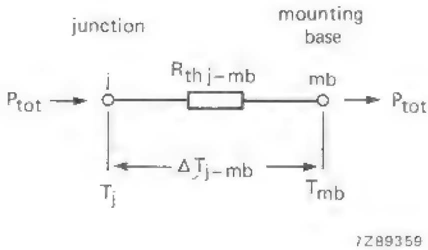


Fig. 2 Heat transport in a transistor with power dissipation constant with respect to time.

By analogy with Ohm's law, under steady-state conditions (d.c. operation)

$$P_{tot} = \frac{T_j - T_{mb}}{R_{th\,j\text{-}mb}}.$$

There are two limitations to P_{tot}
– When $T_{mb} \leqslant T_{mb\,spec}$

$$P_{tot\,max} = \frac{\Delta T_{j\text{-}mb\,max}}{R_{th\,j\text{-}mb}}.$$

– when $T_{mb} > T_{mb\,spec}$

$$P_{tot\,max} = \frac{\Delta T_{j\,max} - T_{mb}}{R_{th\,j\text{-}mb}}$$

$T_{mb\,spec}$ being the mounting base temperature at which $P_{tot\,max}$ is specified in the data sheets, and

$$\Delta T_{j\text{-}mb\,max} = T_{j\,max} - T_{mb\,spec}.$$

For pulsed operation a higher dissipation is permitted, because

– the junction does not have time to heat up fully unless the pulses are so long as to approximate steady-state conditions;
– the junction has time wholly or partly to cool down in the interval between pulses, except with very high duty factors.

Analogy with

$$P_{tot} = \frac{T_j - T_{mb}}{R_{th\,j\text{-}mb}}$$

yields

$$P_{tot\,M} = \frac{T_j - T_{mb}}{Z_{th\,j\text{-}mb}}$$

where $P_{tot\,M}$ is the total pulsed power and $Z_{th\,j\text{-}mb}$ is the thermal impedance between junction and mounting base. Thermal impedance depends on pulse duration t_p and duty factor $\delta = t_p/T$. T is the pulse period. A family of curves of thermal impedance against pulse duration with duty factor as parameter is shown in Fig. 3.

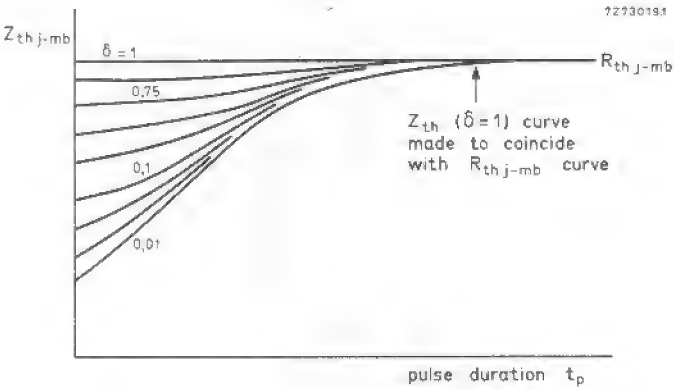


Fig. 3 A typical family of $Z_{th\,j\text{-}mb}$ curves for a power transistor.

Similar limitations apply as in the steady-state conditions:

(a) When $T_{mb} \leqslant T_{mb\,spec}$

$$P_{tot\,M\,max} = \frac{T_{j\text{-}mb\,max}}{Z_{th\,j\text{-}mb}}$$

(b) When $T_{mb} > T_{mb\,spec}$

$$P_{tot\,M\,max} = \frac{T_{j\,max} - T_{mb}}{Z_{th\,j\text{-}mb}}.$$

In essence, at or below $T_{mb\,spec}$ there is a fixed limit to $P_{tot\,M\,max}$; above $T_{mb\,spec}$, $P_{tot\,M\,max}$ declines linearly with increasing mounting base temperature. As illustrated in Fig. 4, for non-rectangular pulses

$$P_{tot\,max} \cdot t_p = \int_{t_1}^{t_2} P \cdot t_p.$$

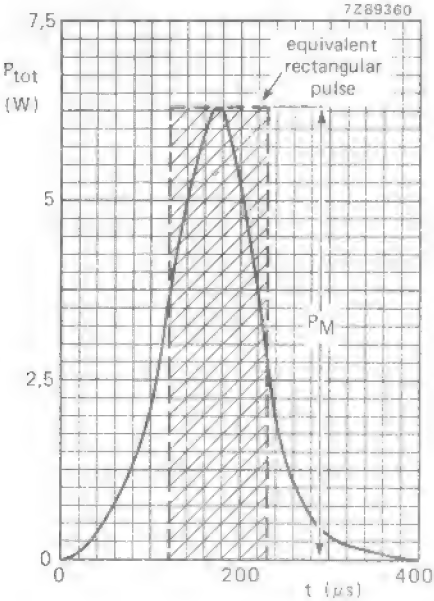


Fig. 4.

Second breakdown

In the forward-biased condition second breakdown is thermally triggered. Consider the chip as a large number of elemental transistors in parallel, some of which will have a lower forward voltage drop than others. Current will tend to concentrate in these, raising their temperature and further lowering their forward voltage drop. Current will concentrate still further, leading to local overheating and eventually to a short circuit between emitter and collector. This effect is independent of mounting base temperature, which is related to the average junction temperature. Under reverse-bias conditions, when V_{CE} is greater than V_{CEOmax}, the chance of second breakdown is always present. This is a particular hazard in timebase and converter applications.

THE SOAR BOUNDARIES

The four limits just described form the boundaries of the Safe Operating ARea. Figure 5 shows a SOAR plotted on a log-log grid. The right-hand boundary is formed by V_{CEOmax}, which extends up to a collector current of about 300 mA. Above this point, as I_C is increased V_{CE} must be reduced to prevent second breakdown.

The upper boundary is formed by I_{Cmax}, which extends to where the product of I_{Cmax} and V_{CE} equals the maximum allowable power dissipation. From this point I_C must be reduced with increasing V_{CE}, thus forming the maximum power dissipation boundary. The maximum power dissipation boundary normally intersects the second breakdown boundary at some point. However, for values of T_{mb} above T_{mbspec}, $P_{tot\,max}$ must be reduced (as shown by the broken line in Fig. 5), so that the boundary of maximum power dissipation intersects the second breakdown boundary at a lower point. With high values of T_{mb}, the second breakdown boundary may be excluded altogether.

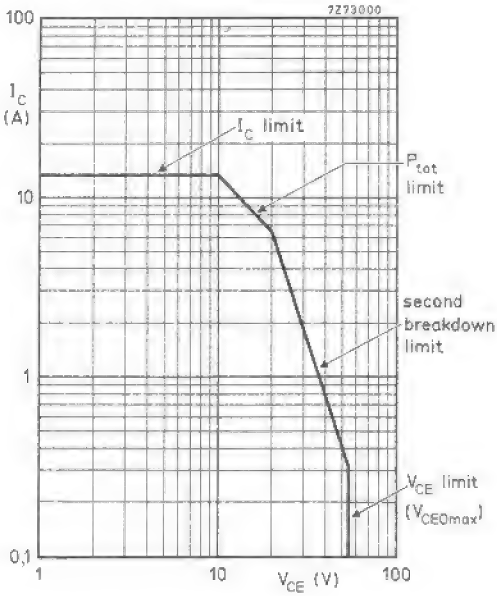


Fig. 5 A typical SOAR graph with boundaries named.

EXTENDING THE SOAR FOR SINGLE-SHOT AND REPETITIVE PULSED OPERATION

The data sheets for power transistors contain, apart from the d.c. SOAR, a set of curves that apply under specific pulse conditions. These will cover some 90% of applications. In addition to these, SOAR curves can be constructed by the circuit designer for specific operating conditions. The various extensions dealt with below will refer to Figs 5, 6 and 8.

I_{CMmax}

The extent to which the I_C boundary can be extended for pulse operation depends on pulse duration and duty factor, the limit being I_{CMmax}, which applies at a duty factor of 0,01 and a pulse length of 20 ms or less. Together the I_{CMmax} and V_{CEOmax} boundaries form a rectangle that in no circumstance should be exceeded. Moreover, the rectangle may be reduced by further restrictions imposed by power dissipation and second breakdown. The example shown in Fig. 6 is for an I_{CMmax} of 12 A and a V_{CEOmax} of 60 V.

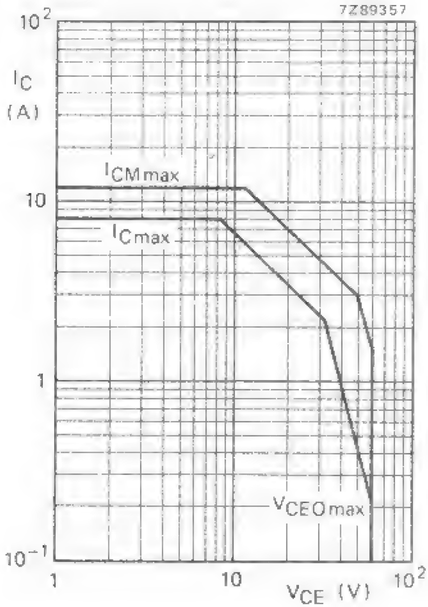


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

$P_{tot\,max}$

The $P_{tot\,max}$ boundary given in the data sheet usually applies to:

T_{mb} = 25 °C; δ = 0,01 and t_p = a range of values, say, 5 μs to 2 ms.

For any deviations from these values a new $P_{tot\,max}$ boundary must be constructed.
From

$$P_{tot\,M\,max} = \frac{T_{j\,max} - T_{mb}}{Z_{th\,j\text{-}mb}};$$

$T_{j\,max}$ is stated in the data sheets; $Z_{th\,j\text{-}mb}$ can be read from the curve, similar to Fig. 3, also given in the data sheets. Thus $P_{tot\,M\,max}$ can be calculated and an appropriate boundary can be drawn in the SOAR curve parallel to the $P_{tot\,max}$ line. An example will illustrate this. Assume:

$T_{j\,max}$ = 150 °C; $T_{mb\,spec}$ = 25 °C; t_p = 0,2 ms and δ = 0,1.

From Fig. 7, $Z_{th\,j\text{-}mb}$ = 0,42 K/W for the given values of t_p and δ.

$$P_{tot\,M\,max} = \frac{150 - 80}{0,42} = 166\ \mathrm{W}.$$

Thus from an arbitary point (say 8,3 A, 20 V) we can draw a line parallel to the $P_{tot\,max}$ line (see Fig. 6).

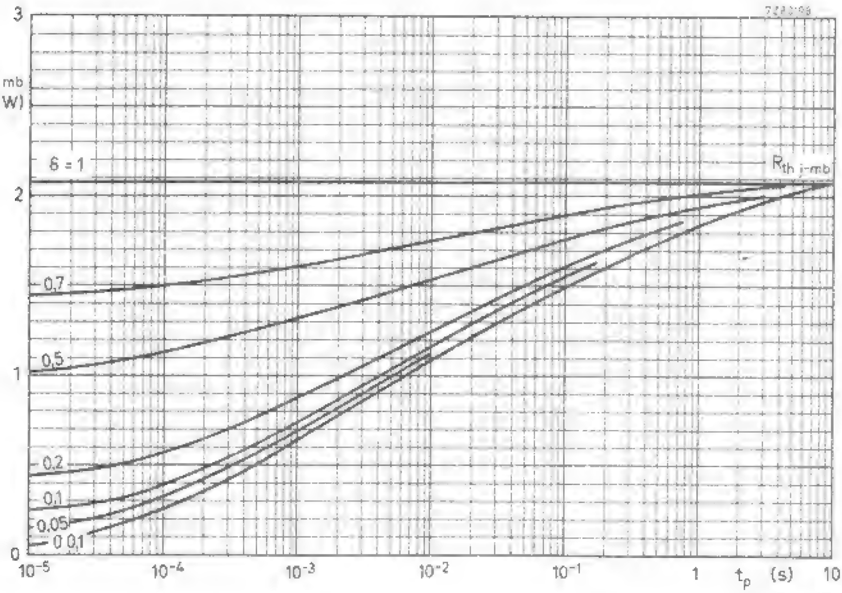


Fig. 7 Transient thermal impedance for example.

Second breakdown

The permissible extension to the second breakdown boundary is found with the aid of two multiplying factors:

M_V — the voltage multiplying factor
M_I — the current multiplying factors.*

Curves for these two factors are given in the data sheets as functions of pulse time with duty factor as parameter (see Fig. 8).

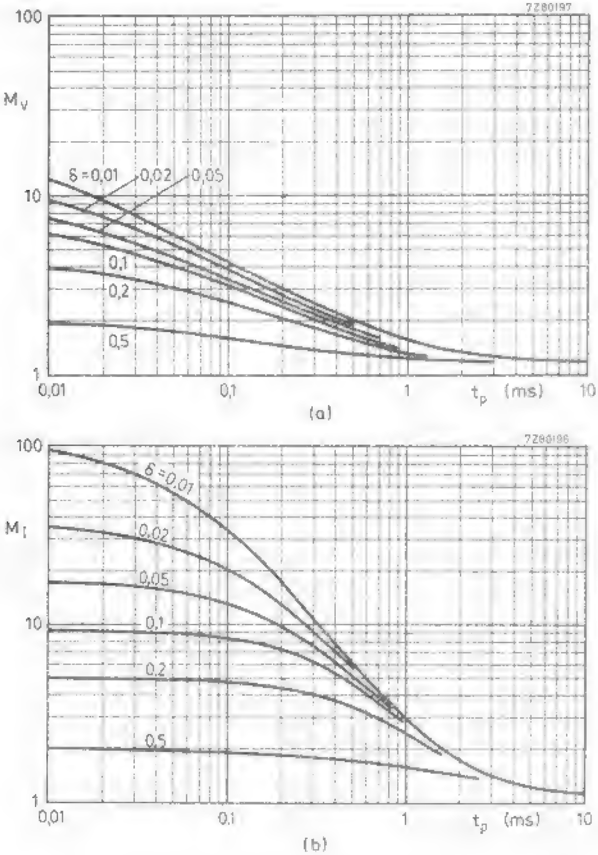


Fig. 8 Second breakdown multiplying factors as a function of pulse time, with duty factor as a parameter.

M_V is used to calculate the point on the V_{CEOmax} boundary at which voltage derating must commence as I_C increases. Similarly, M_I is used to calculate the point on the I_{CMmax} line at which current derating must commence as V_{CE} increases.

* Prior to 1973 M_V was known as $M_{SB(I)}$ and M_I as $M_{SB(V)}$.

Referring to Fig. 9, where B is the point on the V_{CEOmax} boundary at which voltage derating commences, B′ can be calculated by:

$$I_{C(B')} = I_{C(B)} \times M_I.$$

Similarly for I_C; although here A, the point on the I_C curve at which current derating commences, is first determined by extending the second breakdown boundary to where the two would intersect if $P_{tot\,max}$ did not intervene. A′ is then given by

$$V_{CA(S')} = V_{CE(A)} \times M_V.$$

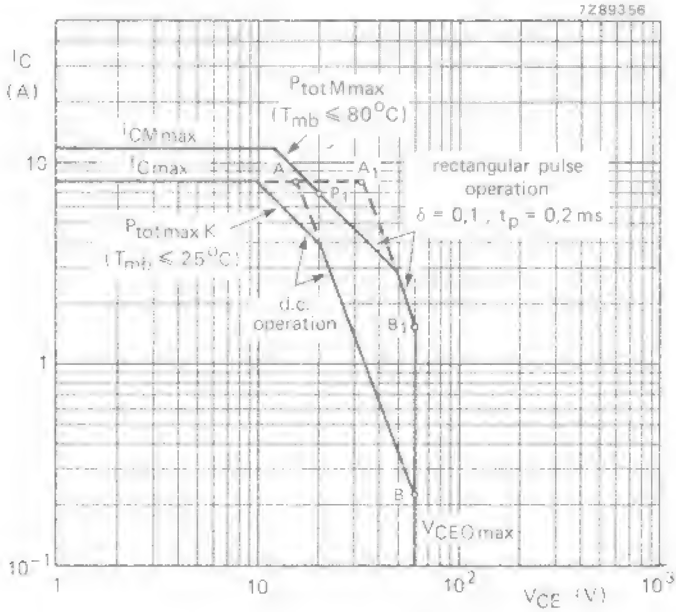


Fig. 9 Construction of the pulse operating area.

An example is worked in Fig. 9 for $t_p = 0{,}2$ ms and $\delta = 0{,}1$.
From Fig. 8, $M_V = 2{,}4$ and $M_I = 7{,}3$:

$$I_{C(B')} = 0{,}22 \times 7{,}3 = 1{,}6 \text{ A}$$
$$V_{CE(A')} = 13 \times 2{,}4 = 31 \text{ V}.$$

These two points are then joined as in Fig. 9.

PULSE TRAINS AND COMPOSITE WAVEFORMS

Straightforward techniques exist for calculating the thermal and second breakdown effects of pulse trains and composite waveforms.

Thermal considerations

Consider a train of rectangular pulses as shown in Fig. 10. The junction will alternately heat and partly cool until a steady-state temperature is reached as shown in the lower part of Fig. 10. To approximate the final junction temperature only the effects of the first two or three pulses need be considered.

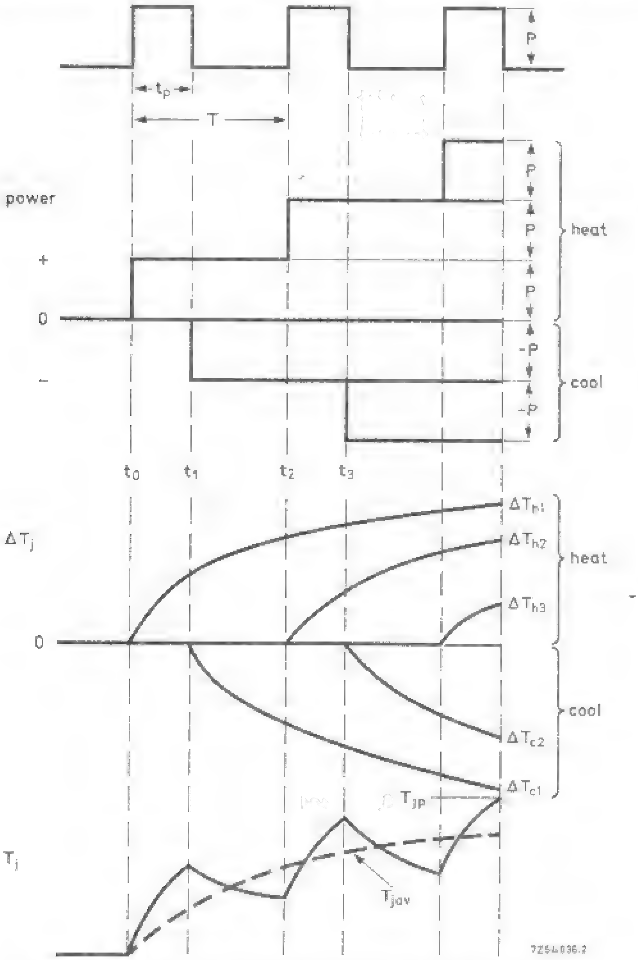


Fig. 10 The heating effect of three equidistant, equal-magnitude pulses. $T_{j\,av}$ is the average junction temperature. P = 100 W, t_p = 100 μs; T = 1 ms and δ = 0,1.

Referring to Fig. 10, where P = 100 W, t_p = 100 μs and δ = 0,1, the first pulse causes the junction to heat up; at the end of the pulse it starts to cool down until the second pulse recommences the heating cycle. We can replace the first pulse with a *continuous* heating pulse at t_0 and a *continuous* cooling pulse starting at t_1. Similarly for the second pulse, we can superimpose a continuous heating pulse starting at t_2 and a cooling pulse starting at t_3. Repeating this for successive pulses allows us to calculate T_j for any point in the pulse train. For instance, the cumulative change in junction temperature at the end of the third pulse is:

$$\Delta T_j = \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2} - \Delta T_{c2} + \Delta T_{h3},$$

where the subscripts h and c refer to heating and cooling respectively. With times taken from Fig. 10,

$T_{h1} = PZ_{th(2,1\ ms)}$
$T_{h2} = PZ_{th(1,1\ ms)}$
$T_{h3} = PZ_{th(0,1\ ms)}$

and

$T_{c1} = -PZ_{th(2,0\ ms)}$
$T_{c2} = -PZ_{th(1,0\ ms)}$

Taking values for Z_{th} from Fig. 11 we get

$$\Delta T_j = 100(0,58 - 0,56 + 0,51 - 0,51 + 0,32) = 34\ ^{o}C.$$

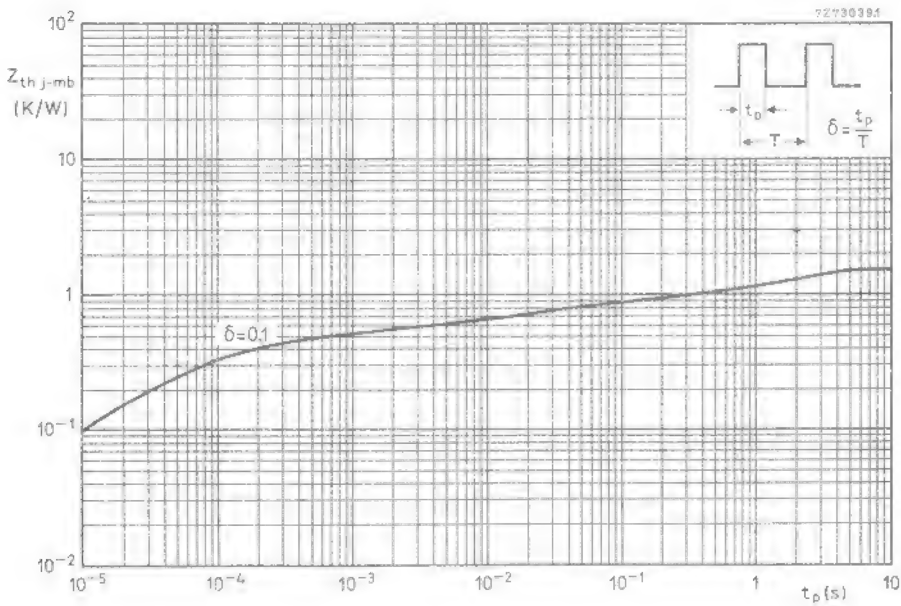


Fig. 11 Curve of $Z_{th\ j\text{-}mb} = f(t_p)$.

The same procedure can be used for long or continuous pulse trains, but calculating for a large number of pulses is very tedious. A sufficiently close approximation can be made by calculating for two pulses, assuming that the first is preceded by a continuous pulse of P_{av} as shown in Fig. 12. By this method

$$\Delta T_j = \Delta T_{h\,av} + \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2}.$$

The calculations are then made as before. To remove any doubt as to the closeness of the approximation the effect of a third pulse can be calculated. Composite waveforms can be treated similarly: divide the composite waveform into equivalent rectangular pulses and calculate the junction temperature accordingly.

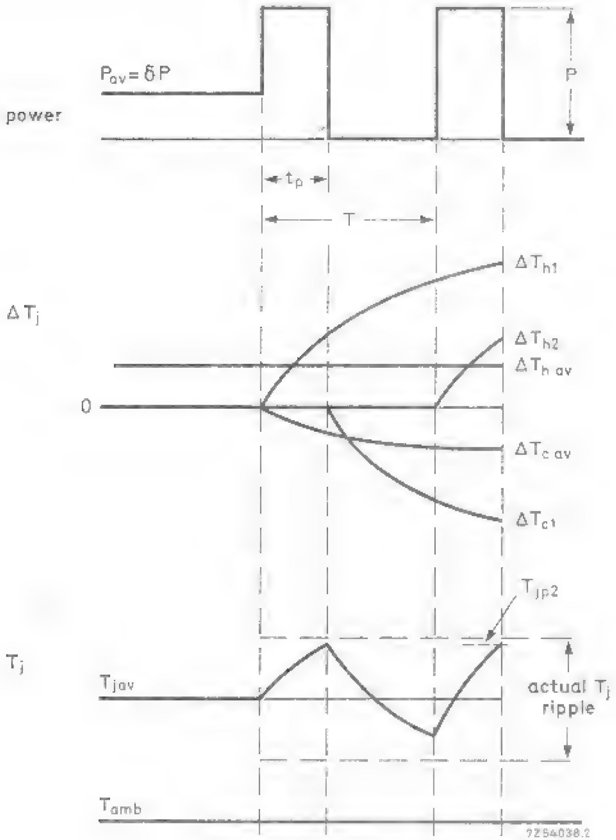


Fig. 12.

Figure 13 shows the current, voltage and power waveforms of the out put transistor in a television receiver vertical output stage. P_{tot} has been divided into four equivalent rectangular parts having the same peak values and energy content as the original waveform.

$$P_{tot\,av} = P_1\delta_1 + P_2\delta_2 + P_3\delta_3 + P_4\delta_4$$
$$= (16 \times 0{,}003) + (13 \times 0{,}11) +$$
$$+ (5{,}2 \times 0{,}66) + (40 \times 0{,}0007)$$
$$= 4{,}936 \text{ W}.$$

Assuming that the $R_{th\ j\text{-}mb}$ for the transistor is 2,5 K/W, the average rise in mounting base temperature will be about 12,5 °C.

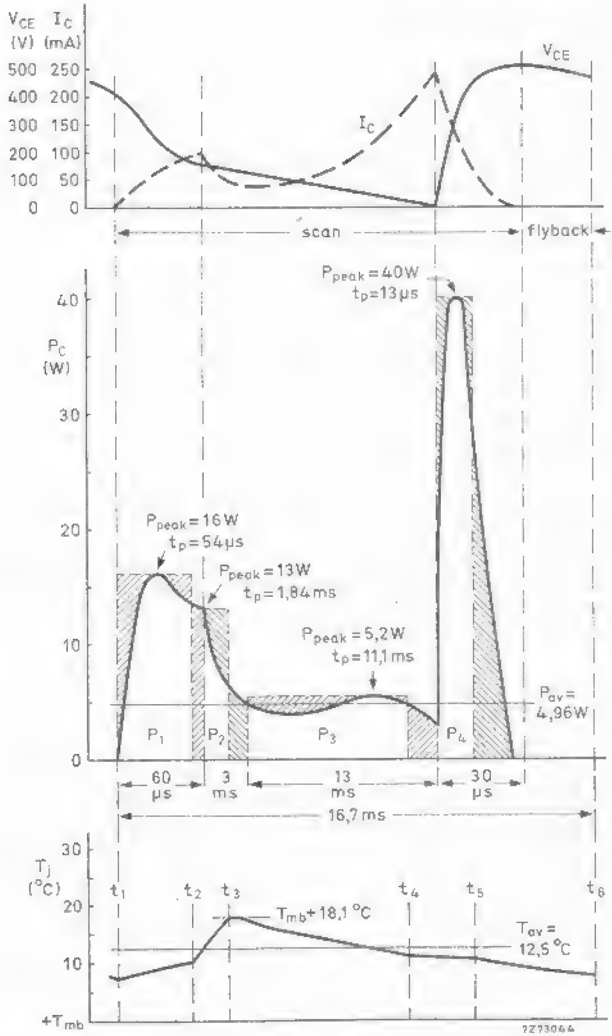


Fig. 13 Power waveforms showing their division into rectangular pulses and the junction temperature variations which they cause.

Using the same method as for pulse trains, peak temperatures at the end of each pulse can be calculated by

$$T_{j\text{-}mb(t1)} = P_{av}R_{th\ j\text{-}mb} - P_{av}Z_{th\ j\text{-}mb(16,1\ ms)} + P_1Z_{th(16,1\ ms)}.$$

For the temperature at the end of the second pulse (t_2) two further terms are added:

$$-P_1Z_{th(16,04\ ms)} + P_2Z_{th(16,04\ ms)}.$$

For t_3 yet another two terms:

$$-P_3Z_{th(13,02\ ms)} + P_4Z_{th(13,03\ ms)}.$$

For each successive pulse a negative term (end of the previous pulse) and a positive term (start of the succeeding pulse) are added. Calculated temperatures are shown in Table 1: note that the highest temperature is reached at the end of pulse 2 (t_3). Even assuming a T_{mb} of 100 °C, T_j will remain within the $T_{j\ max}$ of 150 °C specified for this transistor.

TABLE 1 Calculated temperatures for the power waveform of Fig. 13.

time	t_1	t_2	t_3	t_4	t_5	$t_6(t_s)$	
$\Delta T_{j\text{-}mb}$	8,54	11,34	18,1	12,76	12,3	8,54	°C

EXAMPLE OF A SOAR CALCULATION

To illustrate the foregoing we will take the example of a BU426A transistor operating in a 200 W switched-mode power supply (SMPS).

Waveforms of collector current, collector-emitter voltage and power dissipation are shown in Figs 14, 15 and 16. These are translated into an equivalent rectangular pulse train in Fig. 17. This will enable us to calculate peak junction temperature at any instant.

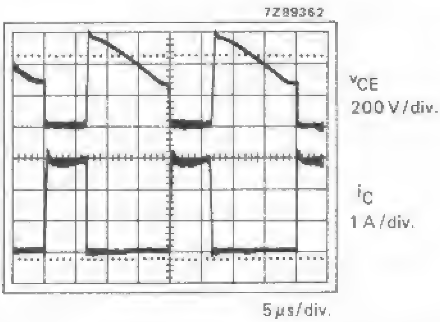


Fig. 14 Collector-current and collector-emitter voltage waveforms of a BU426A transistor in a 200 W SMPS.

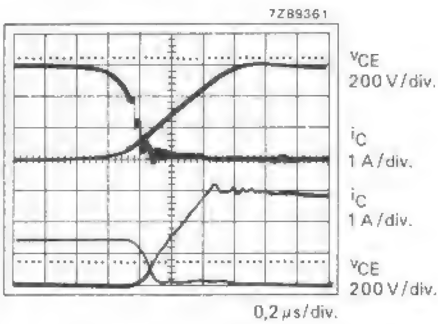


Fig. 15 Waveforms during turn-on and turn-off (lower part).

The duration of this equivalent pulse train is then given by

$$t_p' = \frac{P_{tot\,av} \times T}{P_M'} \text{ and } \delta' = \frac{t_p'}{T}.$$

First, from Fig. 17, heating and cooling pulses are plotted as in Fig. 18. Parameters are then tabulated as shown:

$P_{turn\text{-}on}$ = 66 W	P_{sat} = 10 W	$P_{turn\text{-}off}$ = 56 W
$t_{p\,on}$ = 0,8 μs	$t_{p\,sat}$ = 2,2 μs	$t_{p\,off}$ = 0,6 μs
δ_{on} = 0,04	δ_{sat} = 0,11	δ_{off} = 0,03

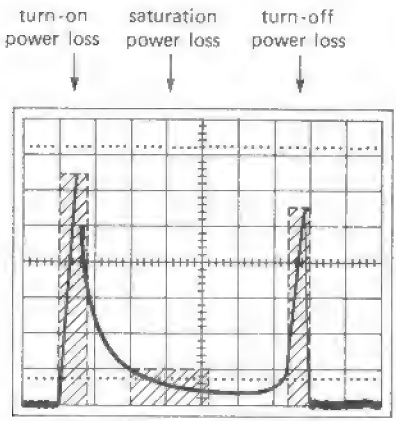


Fig. 16 Power loss and resultant rectangular power pulses.

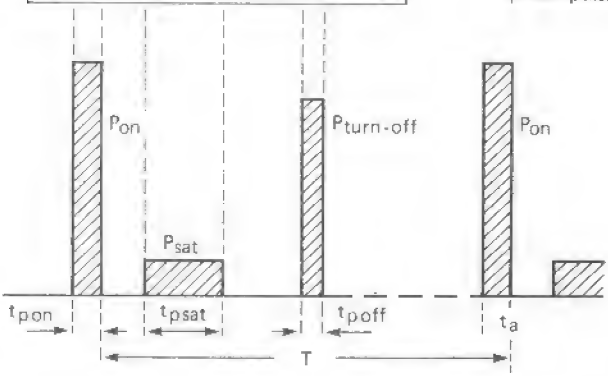


Fig. 17.

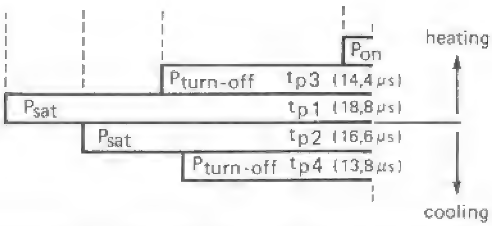


Fig. 18.

From Fig. 17 we can determine δ_p and t_p for each condition and from the BU426 data sheets the relevant Z_{th}.

	p1	p2	p3	p4	p5	unit
t	18,8	16,6	14,4	13,8	0,8	μs
δ	0,94	0,83	0,72	0,7	0,04	
Z_{th}	1,05	0,95	0,85	0,8	0,06	K/W

From

$$\Delta T_j = \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2} - \Delta T_{c2} + \Delta T_{h3}$$

$$\Delta T_{j\text{-mb(ta)}} = (P_{sat} \times Z_{th(tp1)}) - (P_{sat} \times Z_{th(tp2)}) +$$
$$+ (P_{turn\text{-}off} \times Z_{th(tp3)}) - (P_{turn\text{-}off} \times Z_{th(tp4)}) + (P_{on} \times Z_{th(tp\,on)})$$

$$\Delta T_{j\text{-mb(ta)}} = 10(1{,}05 - 0{,}95) + 56(0{,}83 - 0{,}8) + 66(0{,}06) = 7{,}76\ \text{K}.$$

Thus, at time t_a the peak junction temperature is 7,76 K higher than the average mounting base temperature. The $\Delta T_{j\text{-mb}}$ arising from the other power pulses can be calculated in the same way.

Average mounting base temperature depends on the size of the heatsink, ambient temperature (T_a) and average dissipation.

From

$$P_{tot\,av} = P_1\delta_1 + P_2\delta_2 + P_3\delta_3 + P_4\delta_4$$

$$P_{tot\,av} = \delta_{on} \times P_{on} + \delta_{sat} \times P_{sat} + \delta_{turn\text{-}off} \times P_{off}$$

$$= 0{,}04 \times 66 + 0{,}11 \times 10 + 0{,}03 \times 56 = 5{,}4\ \text{W}.$$

Assuming a maximum mounting base temperature of 100 ^oC and an ambient temperature of 60 ^oC the thermal resistance of the heatsink required will be

$$R_{th\,mb\text{-}a} = \frac{T_{mb} - T_a}{P_{tot\,av}} = \frac{100 - 60}{5{,}4} = 7{,}4\ \text{K/W}.$$

If this is the case, the peak junction temperature at the end of the turn-on power pulse will be 107,76 ^oC, which is well within the maximum allowable junction temperature of 150 ^oC.

The pulse SOAR can be calculated using M_I, M_V and Z_{th} factors as described earlier. The turn-on, saturation and turn-off power pulses should be combined into a single pulse of amplitude P' equal to the highest amplitude power pulse (here, P_{on}) and duration t'_p.

$$P_{tot\,av} = P' = 66\ \text{W}.$$

$$\delta' = \frac{5{,}4}{66} = 0{,}082.$$

$$t'_p + \delta' T = 1{,}64\ \mu s.$$

From the BU426A data, for this power pulse $Z_{th\,j\text{-}mb} = 0{,}10$ K/W; $M_I \approx 12$; $M_V \approx 7{,}5$; $V_{CE(A')} = 7{,}5 \times 12 = 90$ V; $I_{C(B')} = 12 \times 40 = 480$ mA.

$$P_{tot\,max} = \frac{T_j - T_{mb}}{Z_{th\,j\text{-}mb}} = \frac{150 - 100}{0{,}1} = 500\ \text{W}.$$

The relevant pulse SOAR is shown in Fig. 19, in which the operating point for the full cycle has also been plotted. It can be seen that it remains well within the SOAR.

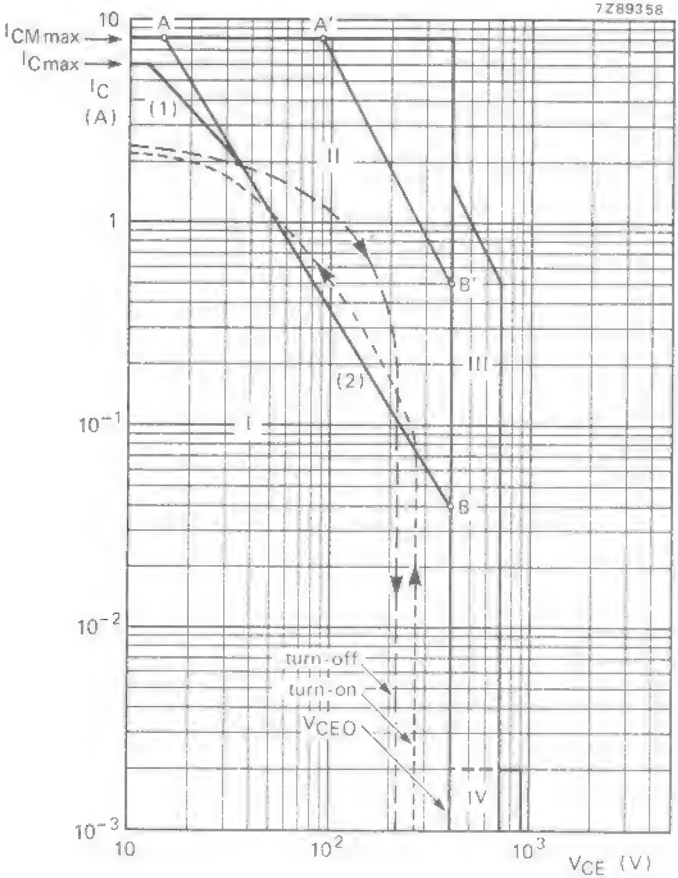


Fig. 19 Safe Operating ARea BU426A at $T_{mb} \leqslant 73\ ^{o}C$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$.

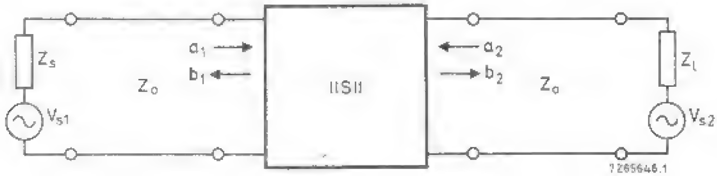
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

SCATTERING PARAMETERS

In distinction to the conventional h, y and z-parameters, s-parameters relate to travelling wave conditions. The figure below shows a two-port network with the incident and reflected waves a_1, b_1, a_2 and b_2.



$$a_1 = \frac{V_{i1}}{\sqrt{Z_o}} \qquad a_2 = \frac{V_{i2}}{\sqrt{Z_o}} \qquad ^{1)}$$

$$b_1 = \frac{V_{r1}}{\sqrt{Z_o}} \qquad b_2 = \frac{V_{r2}}{\sqrt{Z_o}}$$

Z_o = characteristic impedance of the transmission line in which the two-port is connected.

V_i = incident voltage

V_r = reflected (generated) voltage

The four-pole equations for s-parameters are:

$$b_1 = s_{11}a_1 + s_{12}a_2$$

$$b_2 = s_{21}a_1 + s_{22}a_2$$

Using the subscripts i for 11, r for 12, f for 21 and o for 22, it follows that:

$$s_i = s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2 = 0}$$

$$s_r = s_{12} = \left.\frac{b_1}{a_2}\right|_{a_1 = 0}$$

$$s_f = s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2 = 0}$$

$$s_o = s_{22} = \left.\frac{b_2}{a_2}\right|_{a_1 = 0}$$

[1]) The squares of these quantities have the dimension of power.

The s-parameters can be named and expressed as follows:

$s_i = s_{11}$ = Input reflection coefficient.
The complex ratio of the reflected wave and the incident wave at the input, under the conditions $Z_l = Z_o$ and $V_{s2} = 0$.

$s_r = s_{12}$ = Reverse transmission coefficient.
The complex ratio of the generated wave at the input and the incident wave at the output, under the conditions $Z_s = Z_o$ and $V_{s1} = 0$.

$s_f = s_{21}$ = Forward transmission coefficient.
The complex ratio of the generated wave at the output and the incident wave at the input, under the conditions $Z_l = Z_o$ and $V_{s2} = 0$

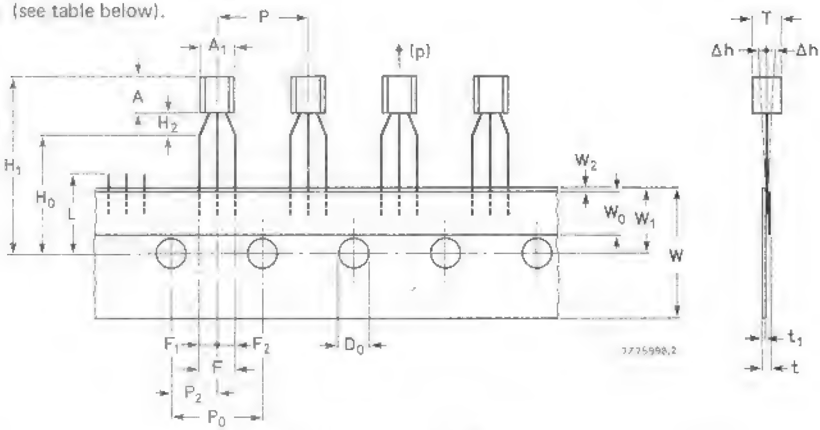
$s_o = s_{22}$ = Output reflection coefficient.
The complex ratio of the reflected wave and the incident wave at the output, under the conditions $Z_s = Z_o$ and $V_{s1} = 0$.

TO-92 VARIANT TRANSISTORS ON TAPE

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see table below).



Item	Symbol	Specifications min.	nom.	max.	tol.	Remarks
Body width	A_1	4,0		4,8		
Body height	A	4,8		5,2		
Body thickness	T	3,9		4,2		
Pitch of component	P		12,7		± 1	
Feed hole pitch	P_0		12,7		± 0,3	Cumulative pitch error 1,0 mm/20 pitch
Feed hole centre to component centre	P_2		6,35		± 0,4	To be measured at bottom of clinch
Distance between outer leads	F		5,08		+ 0,6 −0,2	
Component alignment	Δh		0	1		At top of body
Tape width	W		18		± 0,5	
Hold-down tape width	W_0		6		± 0,2	
Hole position	W_1		9		+ 0,7 −0,5	
Hold-down tape position	W_2		0,5		± 0,2	
Lead wire clinch height	H_0		16		± 0,5	
Component height	H_1			32,25		
Length of snipped leads	L			11,0		
Feed hole diameter	D_0		4		± 0,2	
Total tape thickness	t			1,2		t_1 0,3-0,6
Lead-to-lead distance	F_1, F_2		2,54		+ 0,4 −0,1	
Clinch height	H_2			3		
Pull-out force	(p)	6N				

PACKING

The transistors are supplied on tape in boxes (ammopack) or on reels. The number per reel is 1600 and per ammobox 2000*.

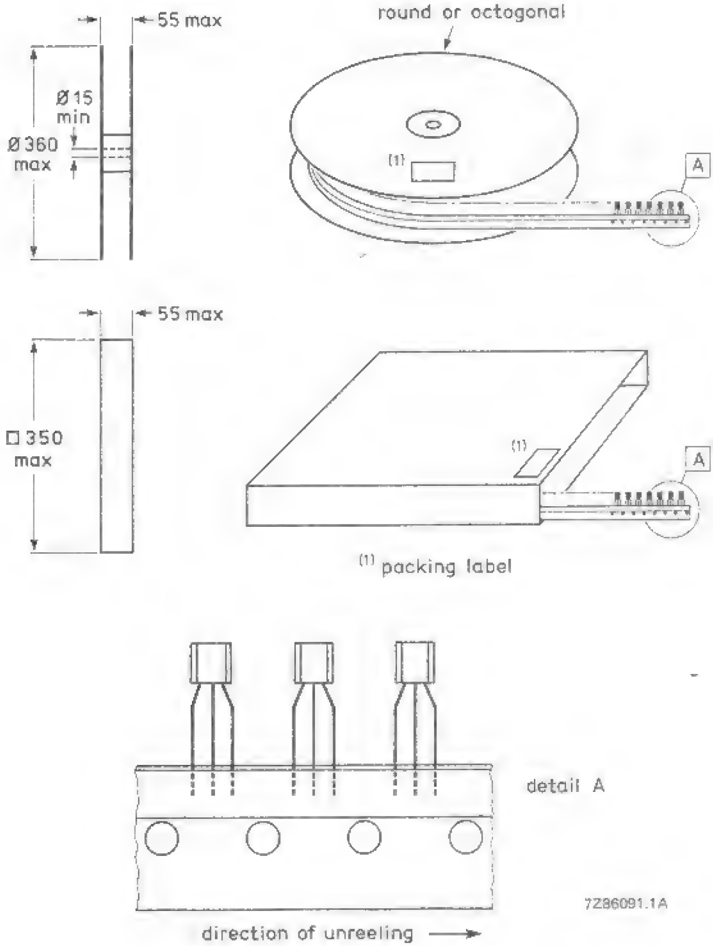


Fig. 2 Dimensions (in mm) of reel and box.

DROPOUTS

A maximum of 0,5% of the specified number of transistors in each packing may be missing. Up to 3 consecutive components may be missing provided the gap is followed by 6 consecutive components.

TAPE SPLICING

Slice the carrier tape on the back and/or front so that the feed hole pitch (P_0) is maintained (see Fig. 3).

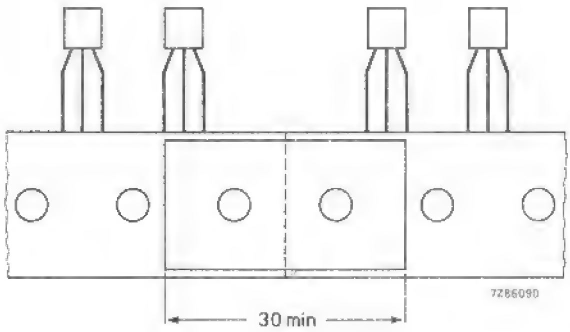


Fig. 3 Jointing tape with splicing patch.

* The ammobox has 80 layers of 25 transistors each.
Each layer contains 25 transistors plus one empty position in order to fold the layer correctly.

The ammobox is accessible from both sides enabling the user to choose between "normal" (see Fig. 2) and "reverse" tape.

SOLDERING RECOMMENDATIONS SOT-37

Transistors in SOT-37 envelopes may be mounted with leads flat (Fig. 1) or bent (Figs 2 and 3). Different soldering procedures apply for the different styles of mounting.

FLAT-LEAD MOUNTING

Soldering by hand

Avoid putting any force on the leads during or just after soldering.

Solder the three leads one at a time, *not* simultaneously.

Proceed from one lead to the adjacent lead, *not* to the opposite one.

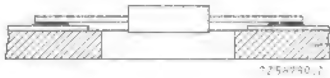


Fig. 1

Solder temperature	max.	300 °C
Soldering time	max.	5 s
Solder-to-case distance	min.	2 mm

BENT-LEAD MOUNTING

If leads are bent, all three may be soldered simultaneously if desired.

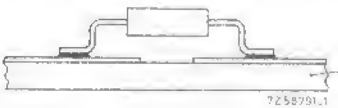


Fig. 2

Solder temperature	max.	300 °C
Soldering time	max.	10 s

DIP OR WAVE SOLDERING

When dip or wave soldering, the maximum allowable temperature of the solder is 260 °C. This temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds. The device may be mounted up to the lead projections, but the temperature of the body must not exceed the specified storage maximum.

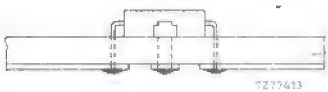


Fig. 3

Solder temperature	max.	260 °C
Soldering time	max.	5 s

TRANSISTOR DATA

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

The **BC107** is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The **BC108** is suitable for multitude of low-voltage applications e.g. driver stages or audio preamplifiers and in signal processing circuits of television receivers.

The **BC109** is primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

QUICK REFERENCE DATA

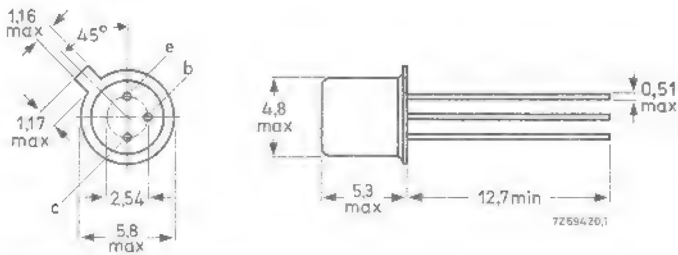
			BC107	BC108	BC109	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	175	175	175	°C
Small-signal current gain at T_j = 25 °C; I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	240	
		<	500	900	900	
Transition frequency at f = 35 MHz; I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V; f = 30 Hz to 15 kHz	F	typ.	–	–	1,4	dB
		<	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1,2	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-076/078, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BC107	BC108	BC109	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	30	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	$^oC/mW$

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150\ ^oC$	I_{CBO}	<	15	μA

Base-emitter voltage[1]

$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	620	mV
		550 to	700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV

[1]) V_{BE} decreases by about 2 $mV/^oC$ with increasing temperature.

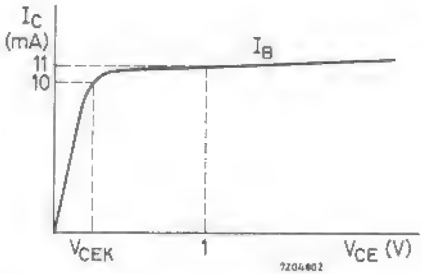
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages [1]

I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
I_C = 100 mA; I_B = 5 mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	2.5	pF
		<	4.5	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; V_{EB} = 0.5 V	C_e	typ.	9	pF

Transition frequency at f = 35 MHz

I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

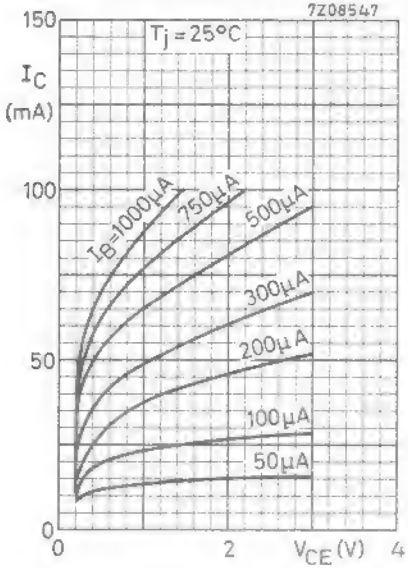
			BC107	BC108	BC109	
Small signal current gain at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

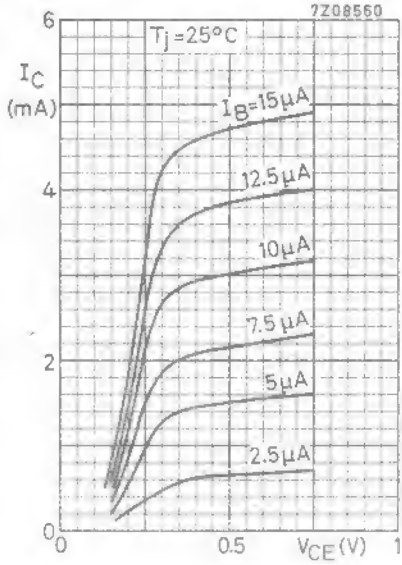
[1] V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

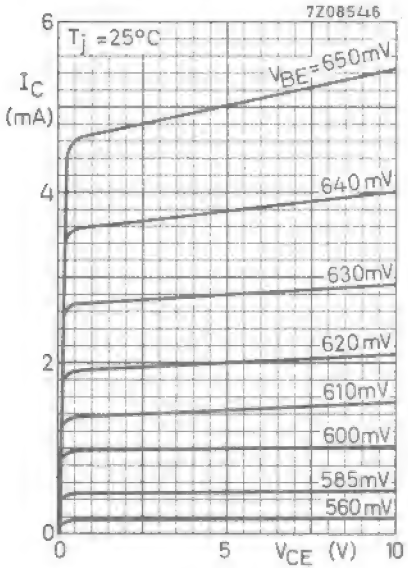
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>		40	100	
		typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	>	1.6	3.2	6	kΩ
		typ.	2.7	4.5	8.7	kΩ
		<	4.5	8.5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	10^{-4}
Small signal current gain	h_{fe}	>	125	240	450	
		typ.	220	330	600	
		<	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu\Omega^{-1}$
		<	30	60	110	$\mu\Omega^{-1}$

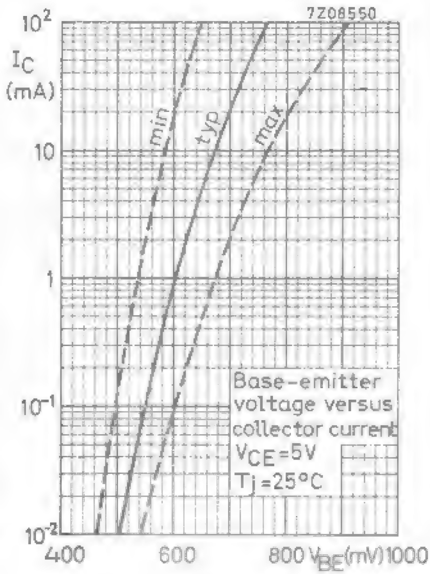
Typical behaviour of collector current versus collector-emitter voltage

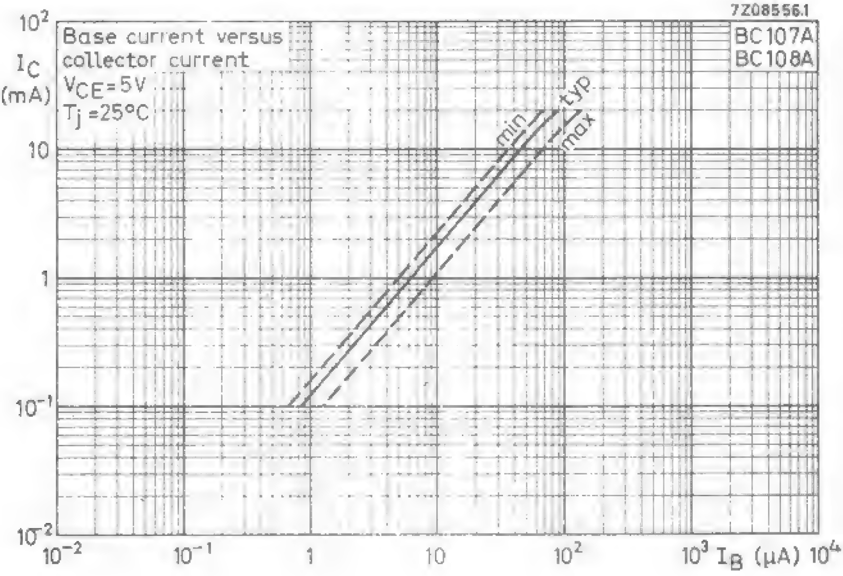


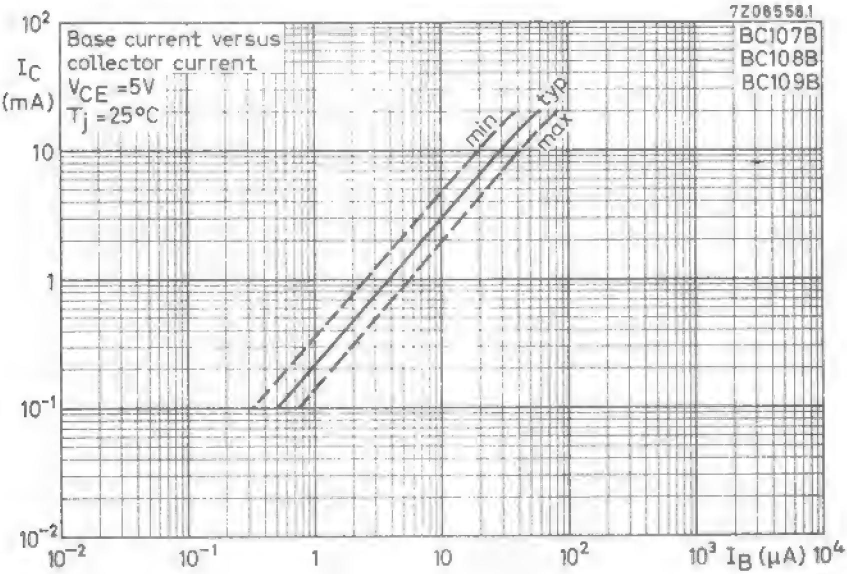


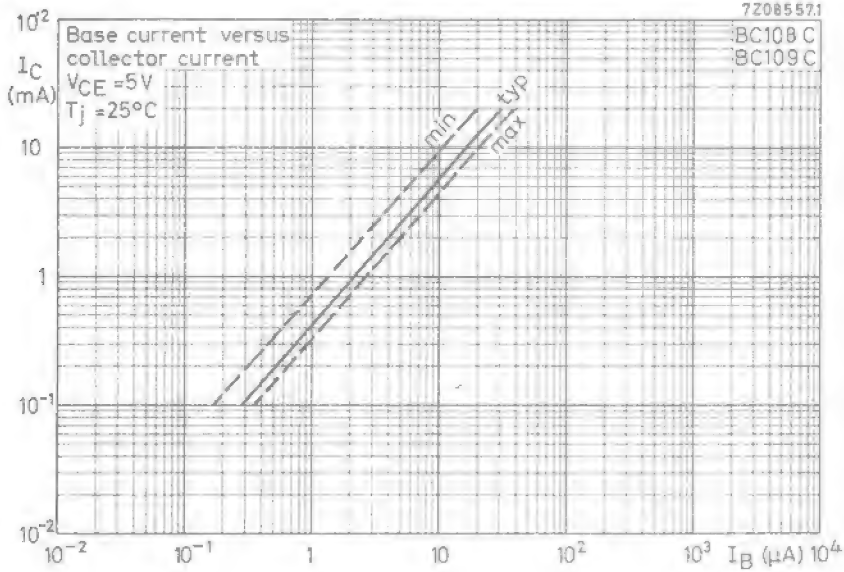
Typical behaviour of collector current versus collector-emitter voltage

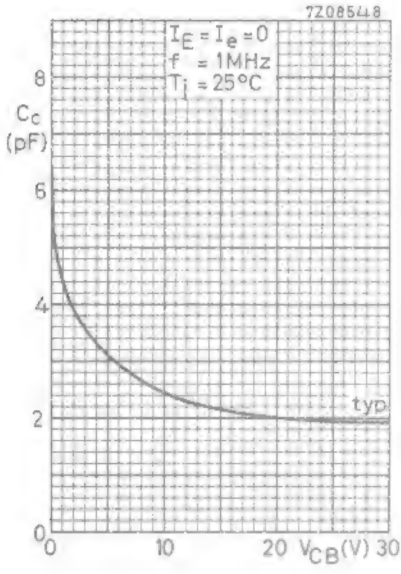


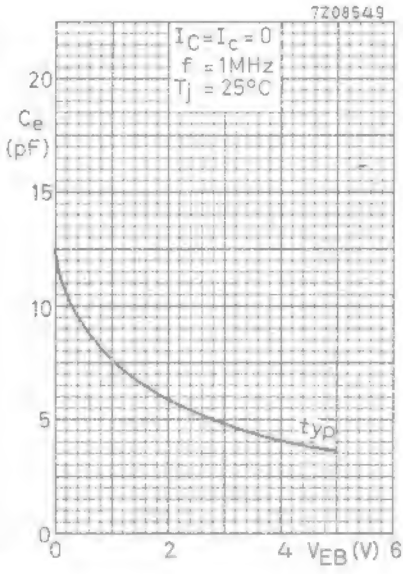


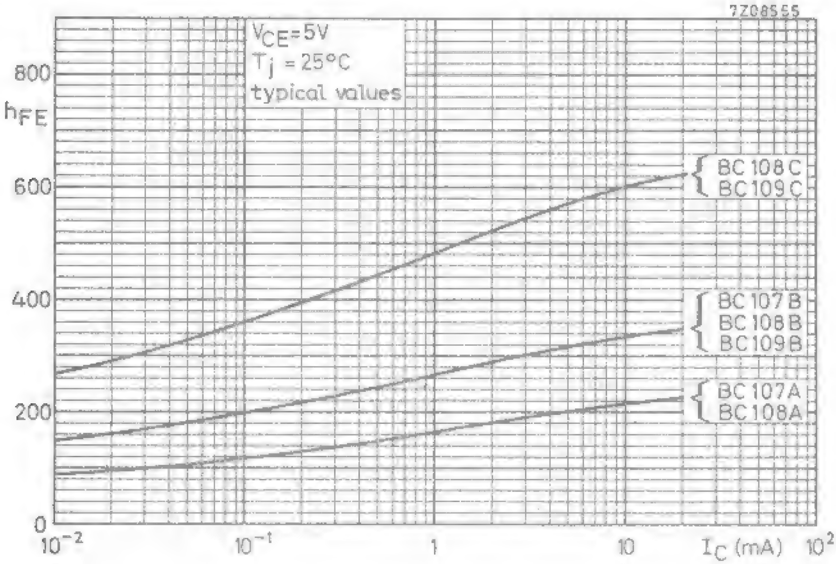

7Z08556.1
Base current versus
collector current
V_{CE}=5V
T_j =25°C
BC107A
BC108A
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4

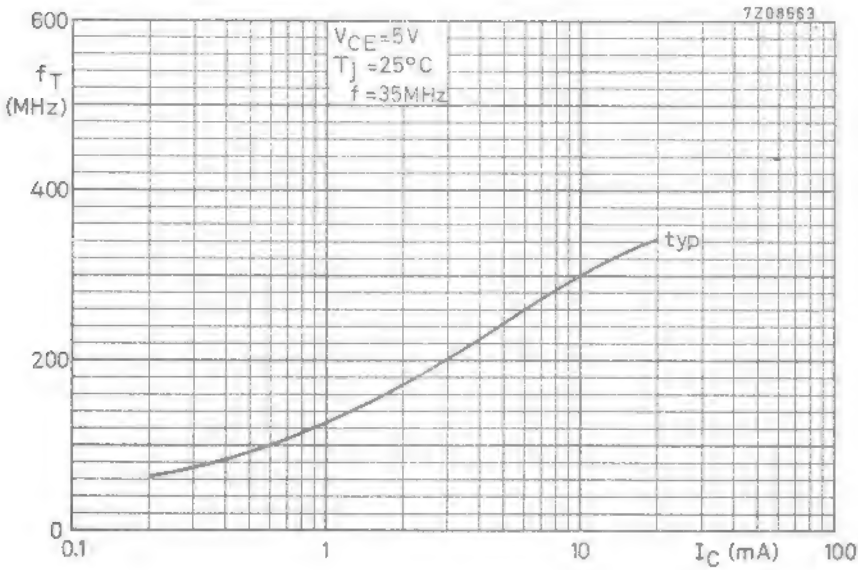

7Z08558.1
Base current versus
collector current
V_{CE} =5V
T_j =25°C
BC107B
BC108B
BC109B
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4


7Z08557.1
Base current versus collector current
V_{CE} = 5 V
T_j = 25 °C
BC108C
BC109C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (µA)
10^4

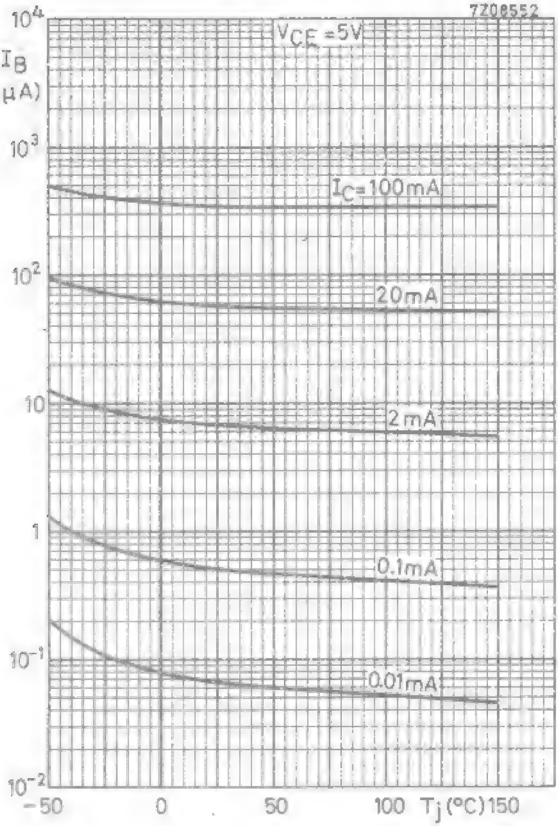

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
8
6
4
2
0
typ
0
10
20
V_{CB} (V)
30

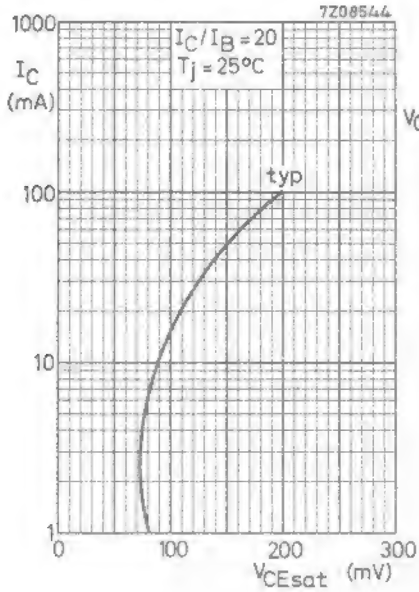

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
20
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

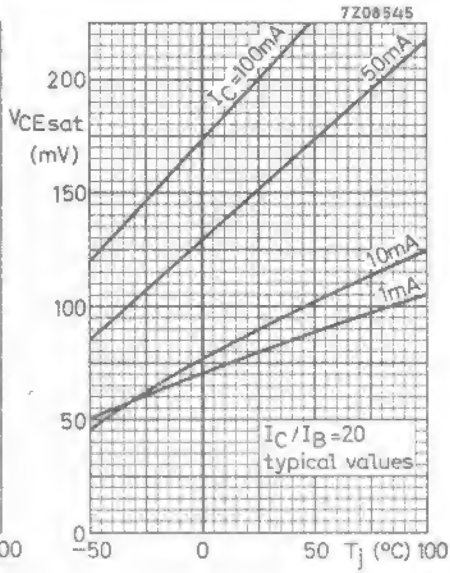

7Z08555
V_{CE}=5V
T_j = 25°C
typical values
h_{FE}
800
600
400
200
0
BC108C
BC109C
BC107B
BC108B
BC109B
BC107A
BC108A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

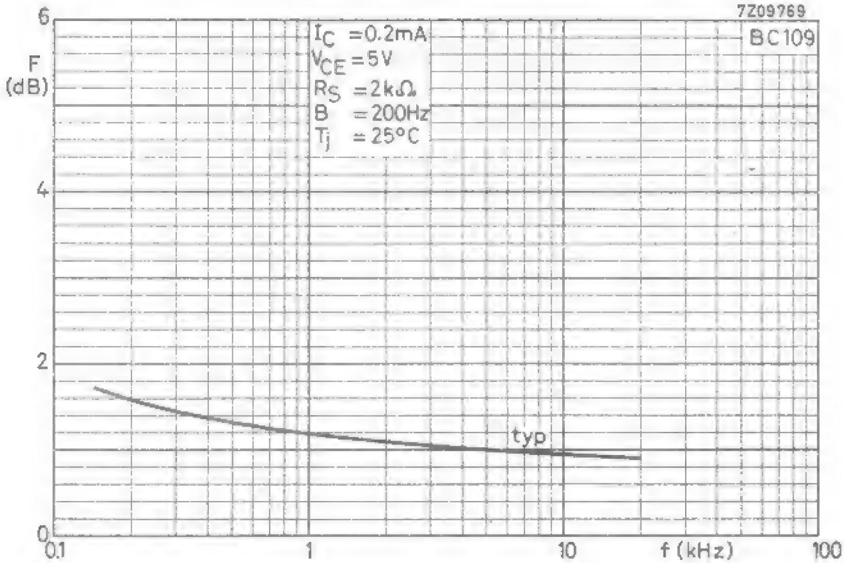

7Z08563
V_{CE}=5V
T_j =25°C
f =35MHz
f_T
(MHz)
600
400
200
0
typ
0.1
1
10
I_C (mA)
100

Typical behaviour of base current
versus junction temperature

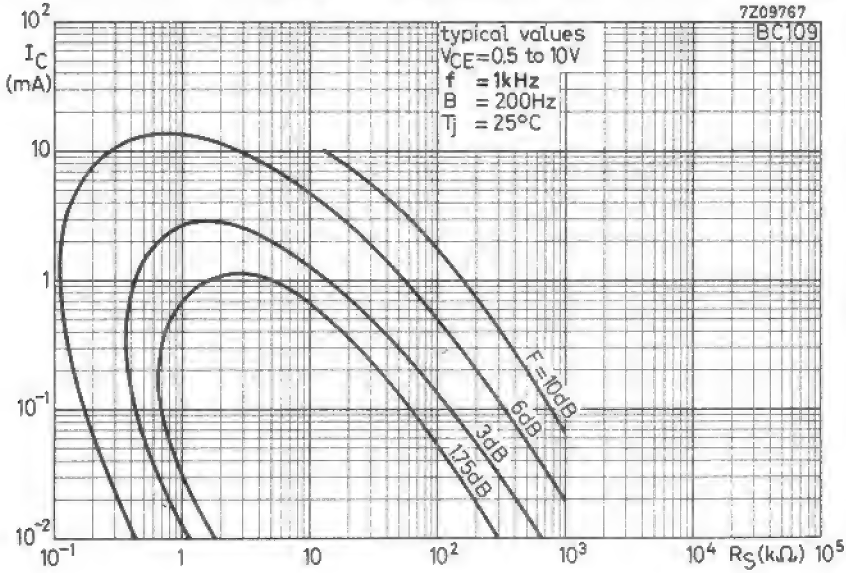


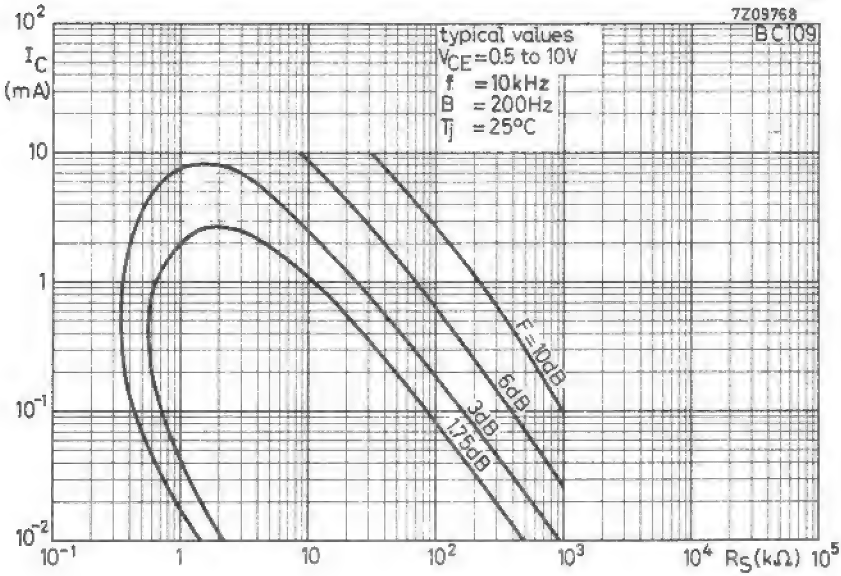

7Z08544
$I_C/I_B = 20$
$T_j = 25°C$
I_C (mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

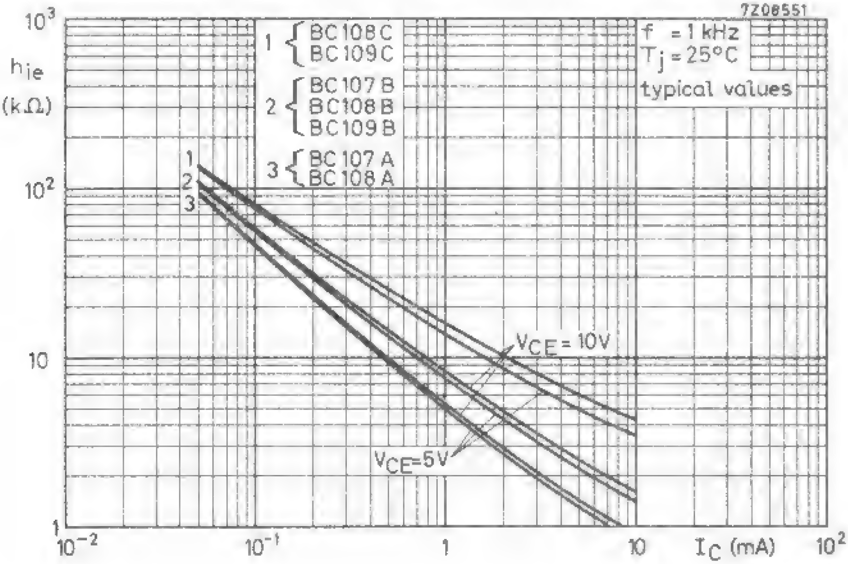

7Z08545
V_{CEsat} (mV)
200
150
100
50
0
I_C = 100mA
50mA
10mA
1mA
$I_C/I_B = 20$
typical values
−50
0
50
100
T_j (°C)

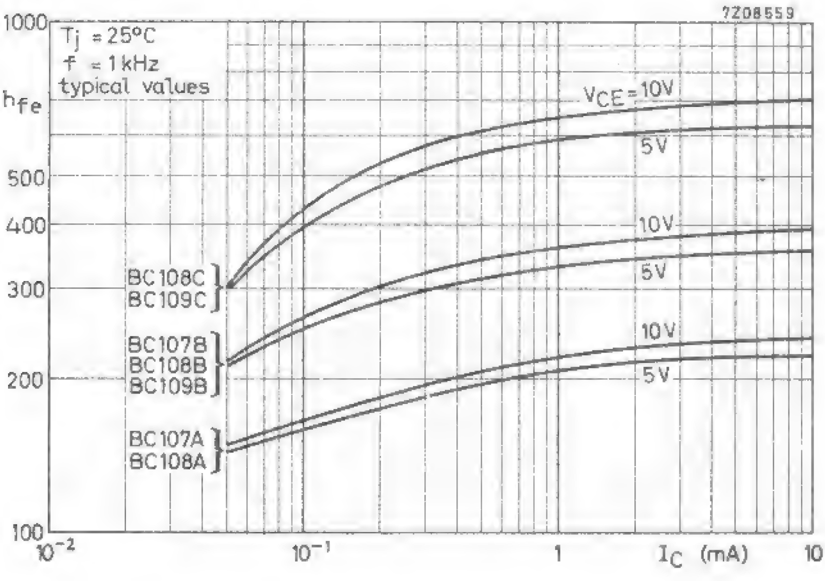

7Z09769
BC109
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
F (dB)
6
4
2
0
typ
0.1
1
10
100
f (kHz)

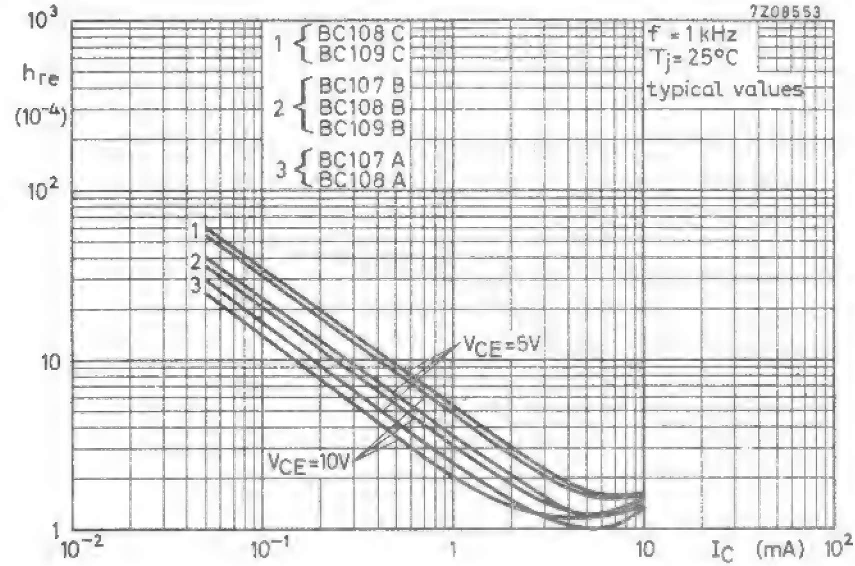
Curves of constant noise figure

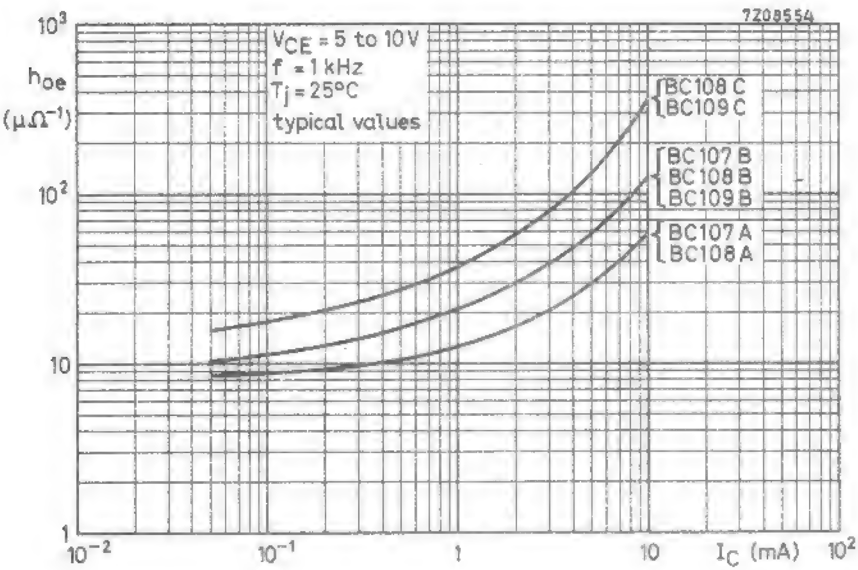


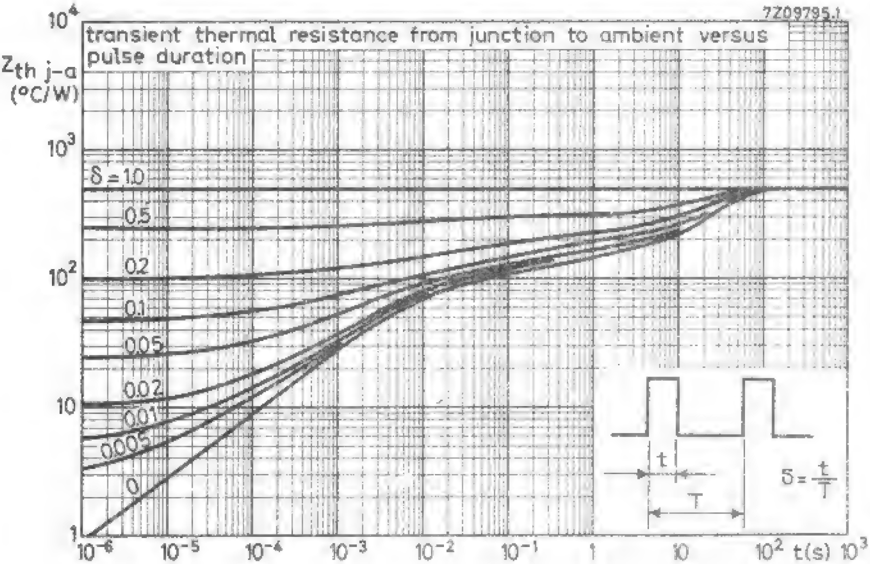



7Z08551
10^3
h_{ie}
(kΩ)
10^2
10
1
1 { BC108C, BC109C
2 { BC107B, BC108B, BC109B
3 { BC107A, BC108A
f = 1 kHz
T_j = 25°C
typical values
V_{CE} = 10V
V_{CE} = 5V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z08559
1000
h_{fe}
500
400
300
200
100
T_j = 25°C
f = 1 kHz
typical values
V_{CE} = 10V
5V
10V
5V
10V
5V
BC108C
BC109C
BC107B
BC108B
BC109B
BC107A
BC108A
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z08553
10^3
h_{re}
(10^{-4})
10^2
10
1
1 { BC108 C, BC109 C
2 { BC107 B, BC108 B, BC109 B
3 { BC107 A, BC108 A
f = 1 kHz
T_j = 25°C
typical values
V_{CE} = 5V
V_{CE} = 10V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z08554
10^3
h_{oe}
$(\mu\Omega^{-1})$
10^2
10
1
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25°C
typical values
BC108 C, BC109 C
BC107 B, BC108 B, BC109 B
BC107 A, BC108 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z09795.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
$\delta = 1.0$
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 t(s) 10^3
t
T
$\delta = \frac{t}{T}$

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes for general purpose applications. P-N-P complements are BC160 and BC161.

QUICK REFERENCE DATA

			BC140	BC141	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Junction temperature	T_j	max.	175		°C
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	50		MHz

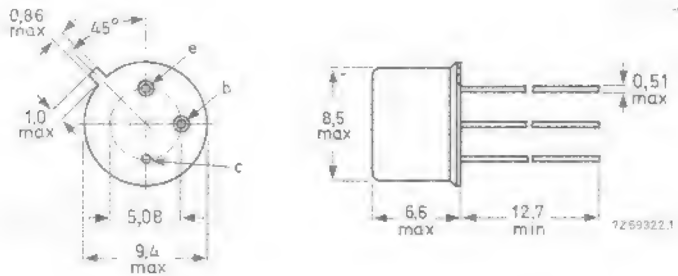
			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC140	BC141	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V
Collector current (d.c.)	I_C	max.	1		A
Base current (d.c.)	I_B	max.	100		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Storage temperature	T_{stg}		−65 to + 175		°C
Junction temperature	T_j	max.	175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	200	K/W
From junction to case	$R_{th\,j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$V_{BE} = 0$; $V_{CE} = 60$ V	I_{CES}	typ.	10	nA
		<	100	nA
$V_{BE} = 0$; $V_{CE} = 60$ V; $T_{amb} = 150$ °C	I_{CES}	typ.	10	μA
		<	100	μA
Base-emitter voltage				
$I_C = 1$ A; $V_{CE} = 1$ V	V_{BE}	typ.	1,2	V
		<	1,8	V
Saturation voltage				
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	typ.	0,6	V
		<	1,0	V
Transition frequency at f = 20 MHz				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	25	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	80	pF

			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16
D.C. current gain					
$I_C = 100$ μA; $V_{CE} = 1$ V	h_{FE}	typ.	28	40	90
		>	40	63	100
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	63	100	160
		<	100	160	250
$I_C = 1$ A; $V_{CE} = 1$ V	h_{FE}	typ.	15	20	30

CHARACTERISTICS (continued)

T_{amb} = 25 °C

Switching times

I_{Con} = 100 mA; I_{Bon} = $-I_{Boff}$ = 5 mA

Turn-on time	t_{on}	<	250 ns
Turn-off time	t_{off}	<	850 ns

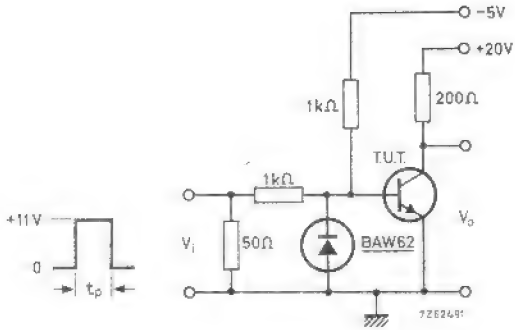


Fig. 2 Test circuit.

Pulse generator:

Pulse duration	t_p	= 10 μs
Rise time	t_r	⩽ 15 ns
Fall time	t_f	⩽ 15 ns
Source impedance	Z_s	= 50 Ω

Oscilloscope:

Rise time	t_r	⩽ 15 ns
Input impedance	Z_i	⩾ 100 kΩ

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a miniature plastic envelope designed for hearing aids, watches, etc.

P-N-P complement is BC200.

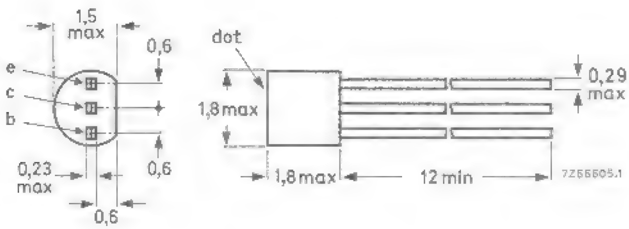
QUICK REFERENCE DATA

			BC146/01	BC146/02	BC146/03	
Collector-base voltage (open emitter)	V_{CBO}	max.	20	20	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	20	20	V
Collector current (d.c.)	I_C	max.	50	50	50	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain I_C = 0,2 mA; V_{CE} = 0,5 V	h_{FE}	>	80	140	280	
		<	200	350	550	
Noise figure at R_S = 2 kΩ I_C = 0,2 mA; V_{CE} = 5 V Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1,5	2	dB
		<	–	4,0	–	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-42.



Coloured dot on top of the black body indicates h_{FE} group:

BC146/01	red
BC146/02	yellow
BC146/03	green

MOUNTING INSTRUCTIONS

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1,5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	mW

Temperature

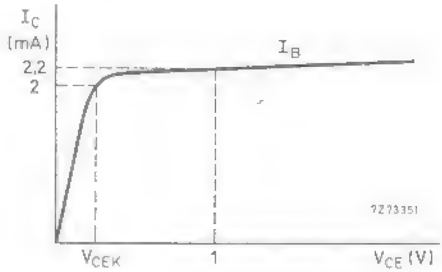
Storage temperature	T_{stg}		−65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	1,6	°C/mW

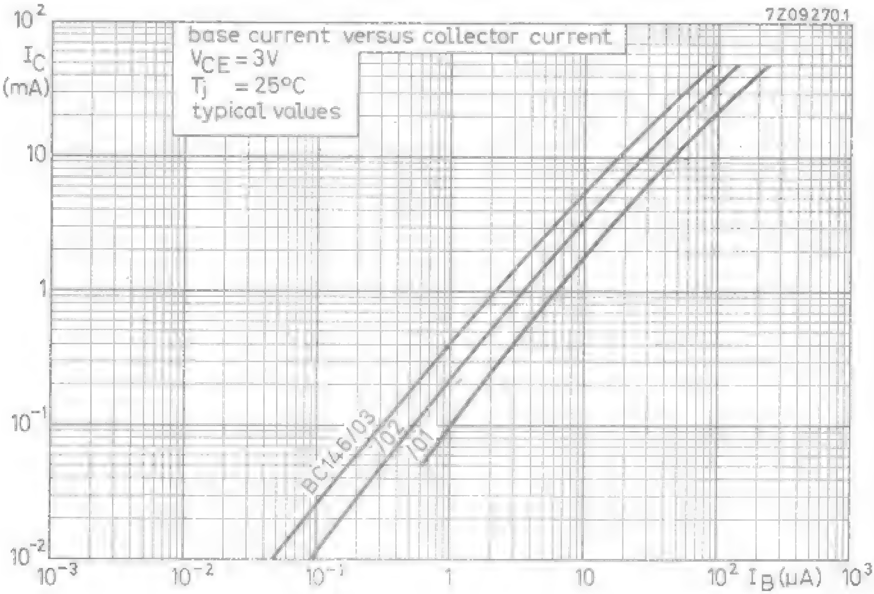
CHARACTERISTICS T_j = 25 °C unless otherwise specified

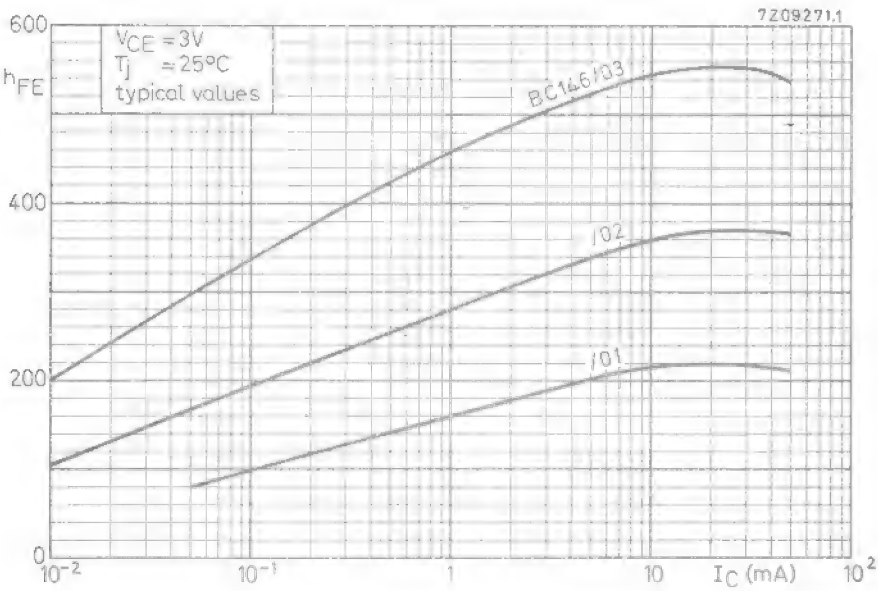
Base-emitter voltage				
I_C = 0,2 mA; V_{CE} = 0,5 V	V_{BE}	typ.	570	mV
I_C = 2 mA; V_{CE} = 1 V	V_{BE}	typ.	630	mV
Knee voltage				
I_C = 2 mA; I_B = value for which I_C = 2,2 mA at V_{CE} = 1 V	V_{CEK}	typ.	180	mV

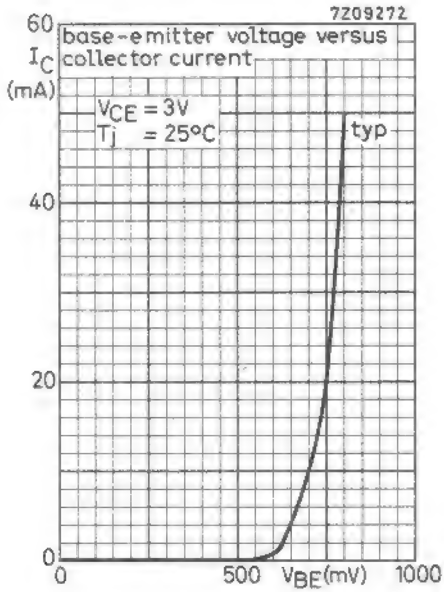


Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 5 V	C_c	typ.	4	pF
Transition frequency				
I_C = 2 mA; V_{CE} = 5 V	f_T	typ.	150	MHz

D.C. current gain	BC146	/01	/02	/03
I_C = 0,2 mA; V_{CE} = 0,5 V	h_{FE}	typ. 115 80 to 200	220 140 to 350	380 280 to 550
I_C = 2 mA; V_{CE} = 1 V	h_{FE}	> 100	140	280
Noise figure				
I_C = 0,2 mA; V_{CE} = 5 V R_S = 2 kΩ Bandwidth: f = 30 Hz to 15 kHz	F	typ. 2 < -	1,5 4	2 dB - dB
h parameters at f = 1 kHz				
I_C = 0,2 mA; V_{CE} = 0,5 V				
Input impedance	h_{ie}	typ. 20	30	45 kΩ
Reverse voltage transfer ratio	h_{re}	typ. 15	25	40 10^{-4}
Small-signal current gain	h_{fe}	typ. 130	220	380
Output admittance	h_{oe}	typ. 15	20	35 µA/V


7Z09270.1
base current versus collector current
V_{CE} = 3V
T_j = 25°C
typical values
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
BC146/03
/02
/01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (μA)
10^3


7Z09271.1
V_{CE} = 3V
T_j = 25°C
typical values
h_{FE}
600
400
200
0
BC146/03
/02
/01
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z09272
base-emitter voltage versus collector current
I_C (mA)
V_{CE} = 3V
T_j = 25°C
typ
60
40
20
0
0
500
V_{BE} (mV)
1000

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes for general purpose applications. N-P-N complements are BC140 and BC141.

QUICK REFERENCE DATA

			BC160	BC161	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Junction temperature	T_j	max.	175		°C
Transition frequency at f = 20 MHz; $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	50		MHz

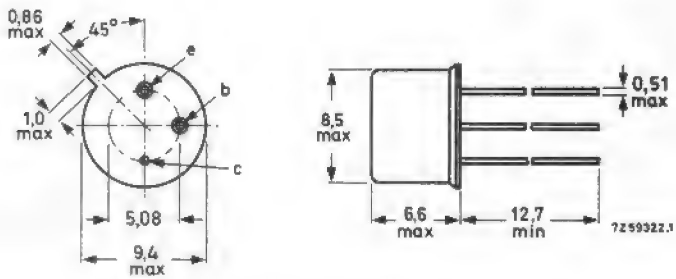
			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC160	BC161	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V
Collector current (d.c.)	$-I_C$	max.	1		A
Base current (d.c.)	$-I_B$	max.	100		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Storage temperature	T_{stg}		−65 to + 175		°C
Junction temperature	T_j	max.	175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	200	K/W
From junction to case	$R_{th\,j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specfied

Collector cut-off current $V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	typ. <	10 100	nA nA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$; T_{amb} = 150 °C	$-I_{CES}$	typ. <	10 100	μA μA
Base-emitter voltage $-I_C$ = 1 A; $-V_{CE}$ = 1 V	$-V_{BE}$	typ. <	1,0 1,7	V V
Saturation voltage $-I_C$ = 1 A; $-I_B$ = 100 mA	$-V_{CEsat}$	typ. <	0,6 1,0	V V
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	<	30	pF
Emitter capacitance at f = 1 MHz $I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	<	180	pF

			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
D.C. current gain $-I_C$ = 100 μA; $-V_{CE}$ = 1 V	h_{FE}	typ.	46	80	120
		>	40	63	100
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	63	100	160
		<	100	160	250
$-I_C$ = 1 A; $-V_{CE}$ = 1 V	h_{FE}	typ.	15	20	30

CHARACTERISTICS (continued)

T_{amb} = 25 °C

Switching times

$-I_{Con}$ = 100 mA; $-I_{Bon}$ = I_{Boff} = 5 mA

Turn-on time	t_{on}	<	500 ns
Turn-off time	t_{off}	<	650 ns

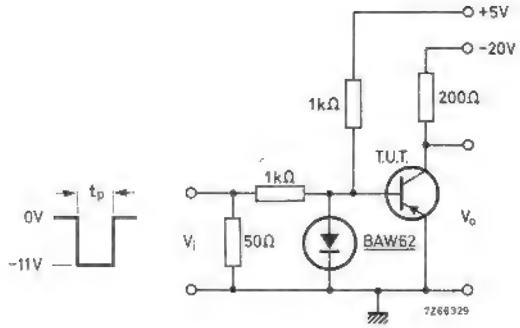


Fig. 2 Test circuit.

Pulse generator:

Pulse duration	t_p	=	10 μs
Rise time	t_r	≤	15 ns
Fall time	t_f	≤	15 ns
Source impedance	Z_s	=	50 Ω

Oscilloscope:

Rise time	t_r	≤	15 ns
Input impedance	Z_i	≥	100 kΩ

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes with the collector connected to the case.

The **BC177** is a high-voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The **BC178** is suitable for a multitude of low-voltage applications e.g. driver stages or audio preamplifiers and in signal processing circuits of television receivers.

The **BC179** is primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

Moreover, they are intended as complementary types for the BC107, BC108 and BC109.

QUICK REFERENCE DATA

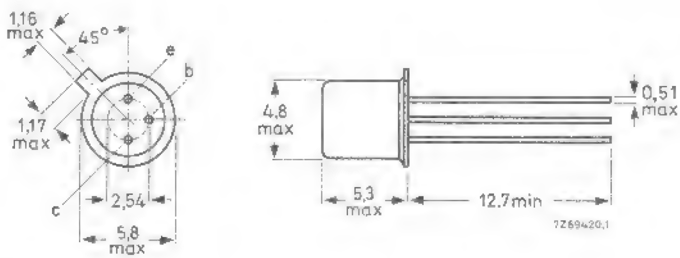
			BC177	BC178	BC179	
Collector-emitter voltage (+ V_{BE} = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	175	175	175	°C
Small-signal current gain at T_j = 25 °C $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	>	75	75	125	
		<	260	500	500	
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	150	150	MHz
Noise figure at R_S = 2 kΩ $-I_C$ = 200 µA; $-V_{CE}$ = 5 V f = 30 Hz to 15 kHz	F	typ.	–	–	1,2	dB
		<	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4,0	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134).

Voltages

			BC177	BC178	BC179	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	30	25	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

CHARACTERISTICS

Collector cut-off current

$I_E = 0$; $-V_{CB}$ = 20 V; T_j = 25 °C	$-I_{CBO}$	typ.	1	nA
		<	100	nA
T_j = 150 °C	$-I_{CBO}$	<	10	μA

Base-emitter voltage [1])

$-I_C$ = 2 mA; $-V_{CE}$ = 5 V; T_j = 25 °C	$-V_{BE}$	typ.	650	mV
			600 to 750	mV

[1]) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

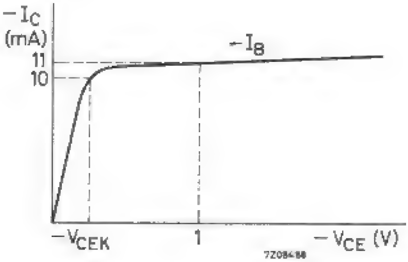
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages

$-I_C$ = 10 mA; $-I_B$ = 0.5 mA	$-V_{CEsat}$	typ.	75	mV
		<	300	mV
	$-V_{BEsat}$	typ.	700	mV
$-I_C$ = 100 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	typ.	250	mV
	$-V_{BEsat}$	typ.	850	mV

Knee voltage

$-I_C$ = 10 mA; $-I_B$ = value for which	$-V_{CEK}$	typ.	250	mV
$-I_C$ = 11 mA at $-V_{CE}$ = 1 V		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	4.0	pF

Transition frequency at f = 35 MHz

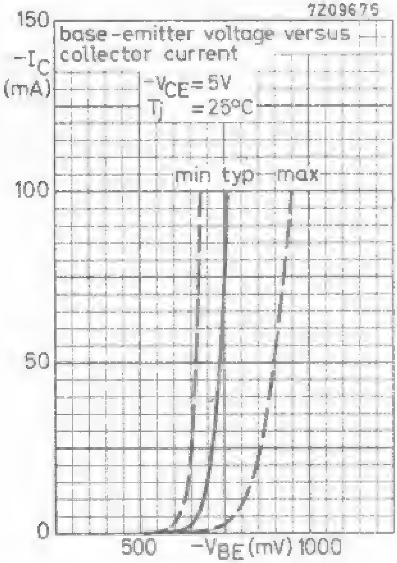
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	MHz

Small signal current gain at f = 1 kHz

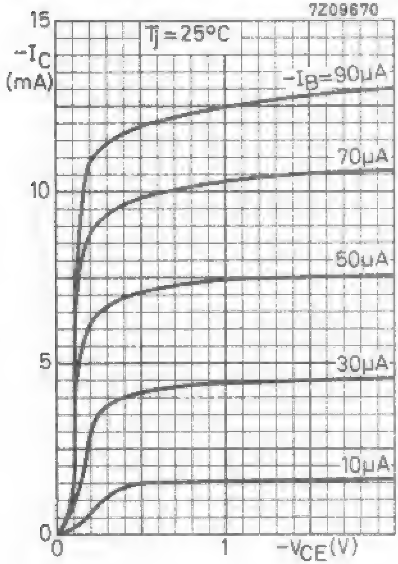
			BC177	BC178	BC179	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

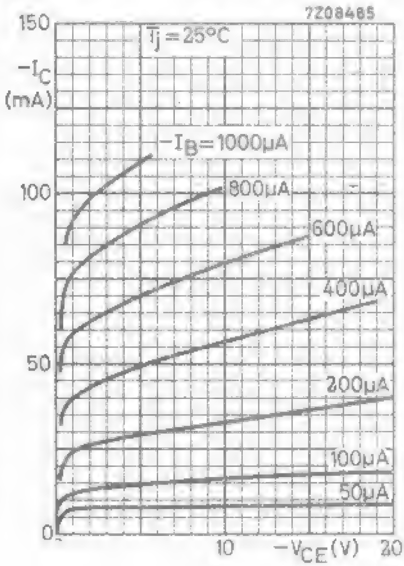
CHARACTERISTICS (continued)

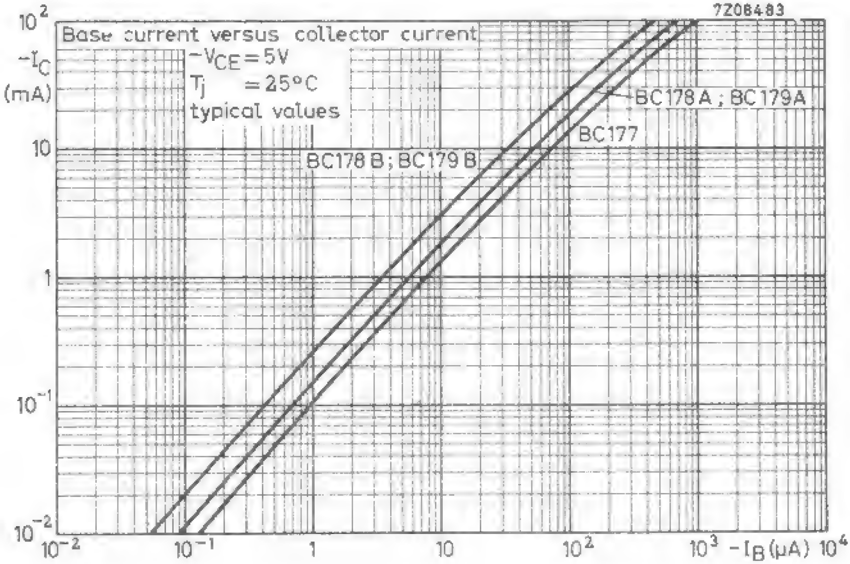
			BC177 BC178	BC177A BC178A BC179A	BC177B BC178B BC179B
D.C. current gain $-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz $-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	125	240
		<	260	260	500

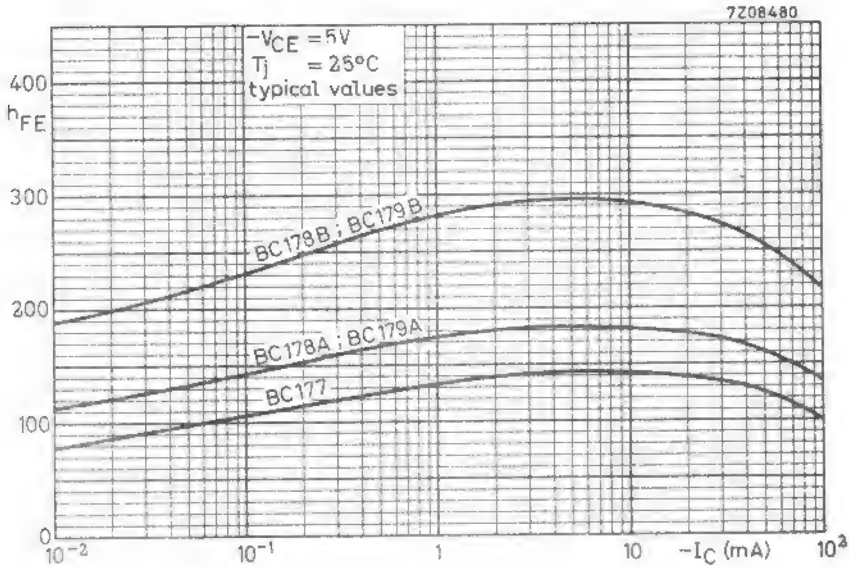


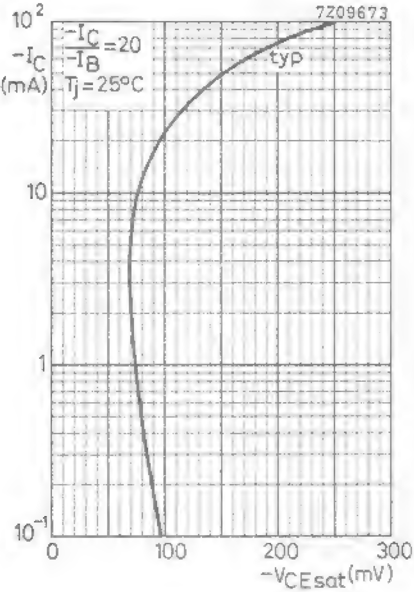
Typical behaviour of collector current versus collector-emitter voltage

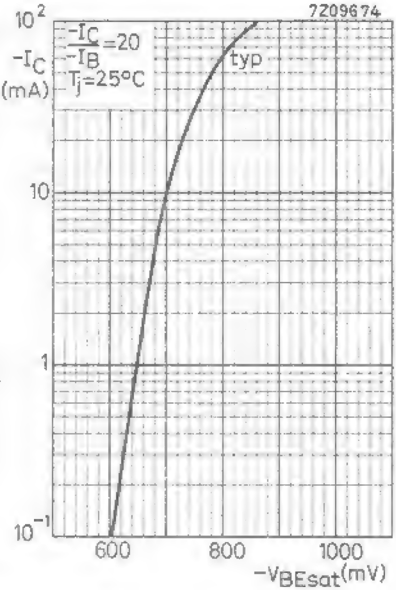


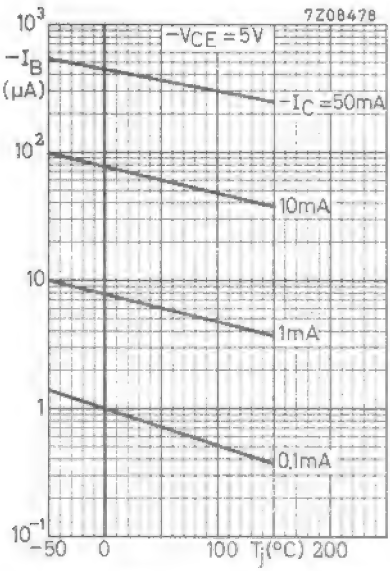



7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
BC178 A ; BC179A
BC177
BC178 B ; BC179 B
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

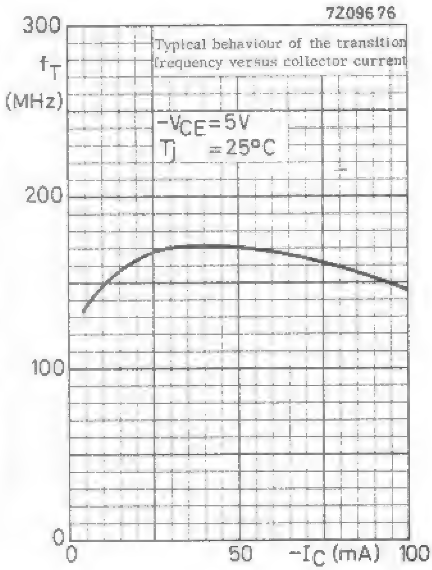

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC178B ; BC179B
BC178A ; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

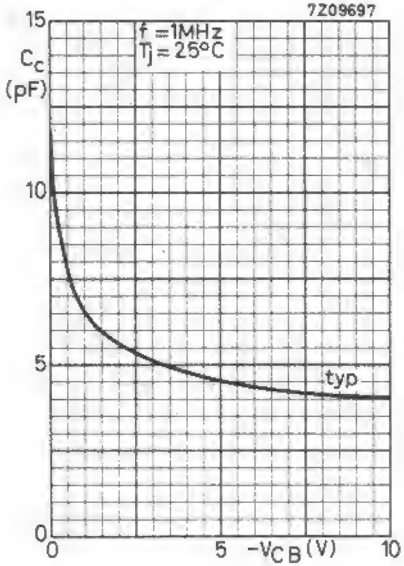


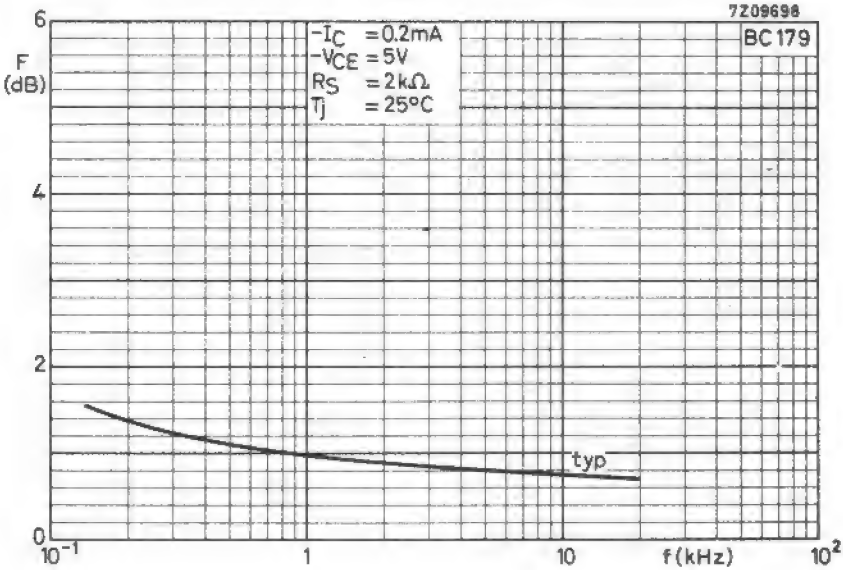




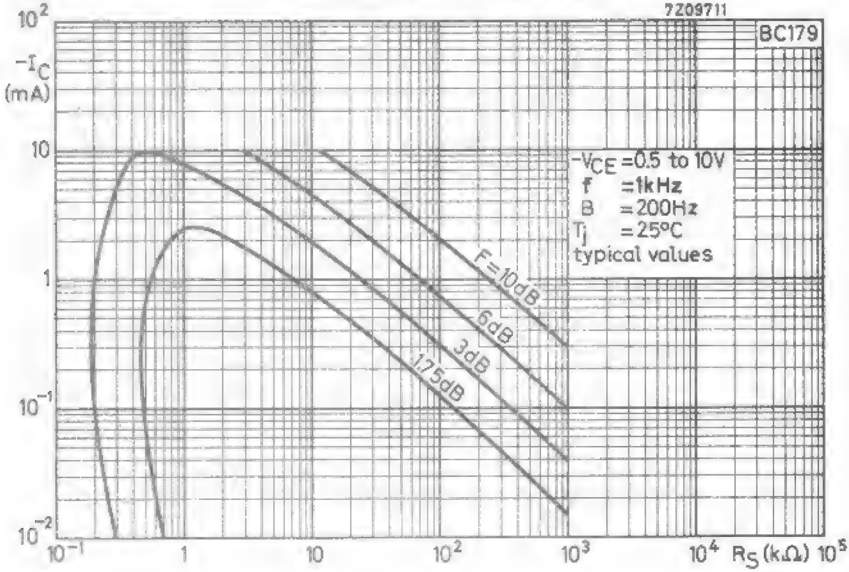
Typical behaviour of base current versus junction temperature

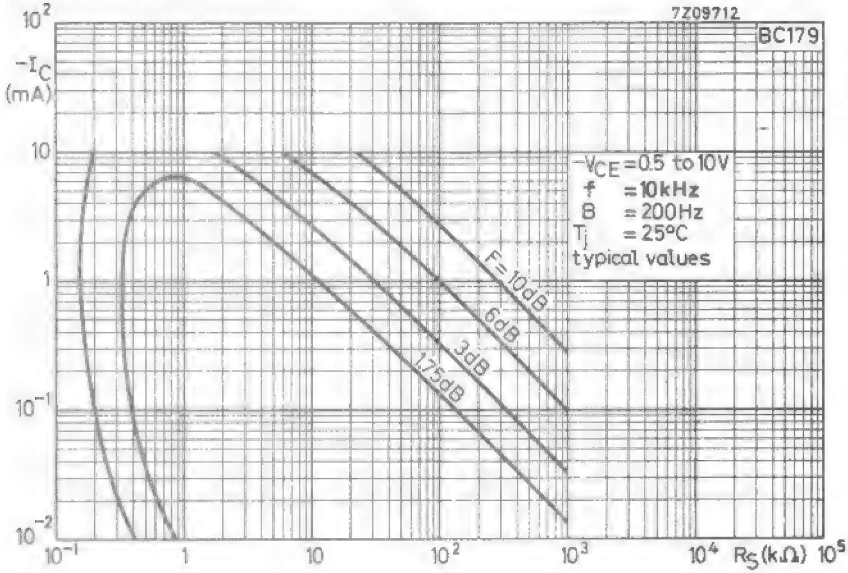


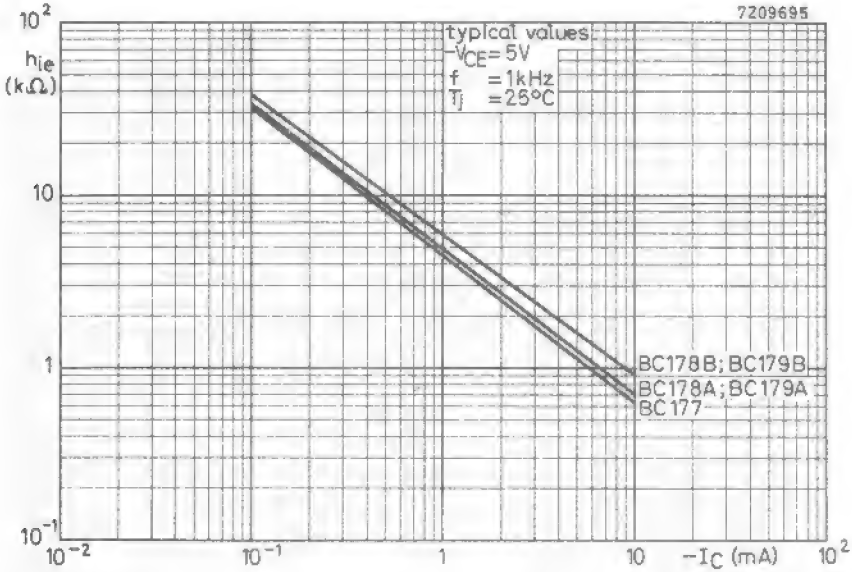

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
-VCB (V)
10

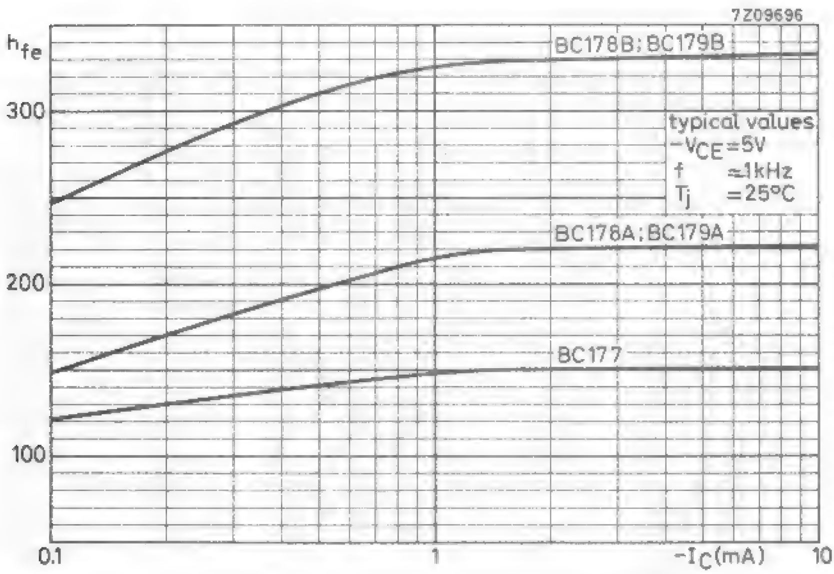

7Z09698
BC 179
-IC = 0.2mA
-VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10^-1
1
10
f (kHz)
10^2

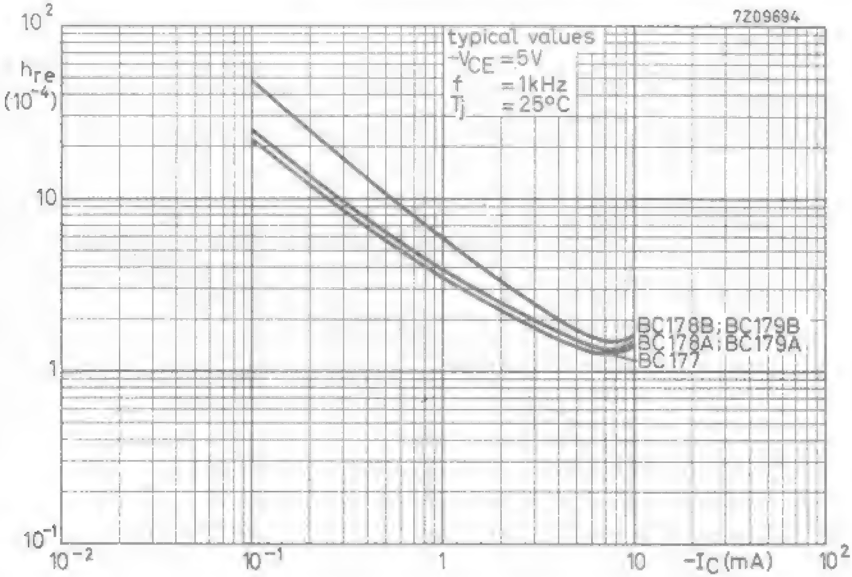
Curves of constant noise figure

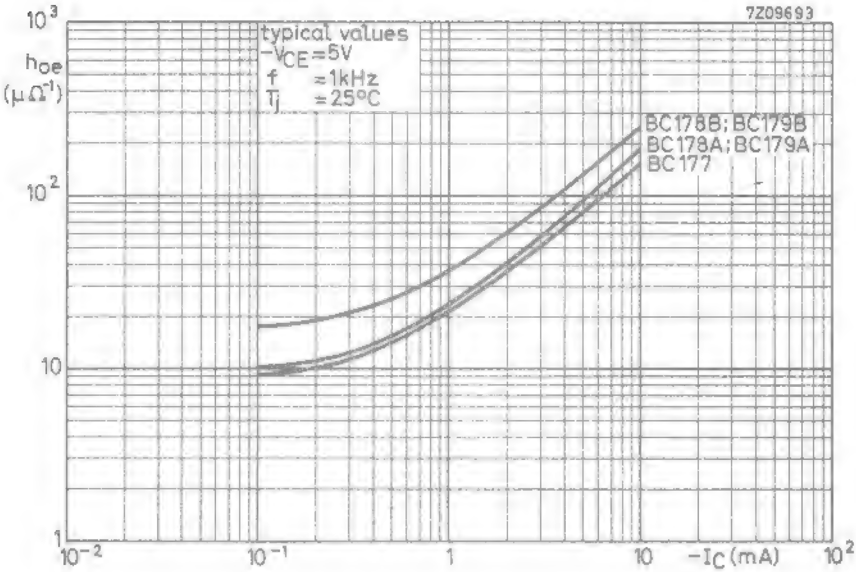


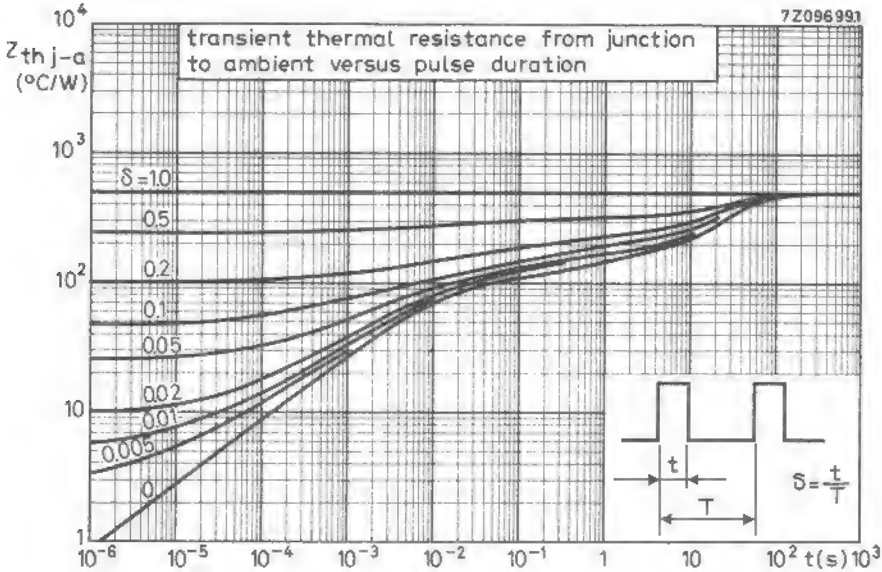



7Z09695
typical values
$-V_{CE} = 5V$
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09696
h_{fe}
300
200
100
BC178B; BC179B
typical values
$-V_{CE} = 5V$
f ≈ 1kHz
T_j = 25°C
BC178A; BC179A
BC177
0.1
1
$-I_C$(mA)
10


7Z09694
typical values
$-V_{CE} = 5V$
$f = 1kHz$
$T_j = 25°C$
h_{re}
(10^{-4})
10^2
10
1
10^{-1}
BC178B; BC179B
BC178A; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09693
typical values
$-V_{CE} = 5V$
$f = 1kHz$
$T_j = 25°C$
h_{oe}
$(\mu\Omega^{-1})$
10^3
10^2
10
1
BC178B; BC179B
BC178A; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09699.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\,j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
$\delta = \frac{t}{T}$

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a miniature plastic envelope designed for hearing aids, watches, etc.
N-P-N complement is BC146.

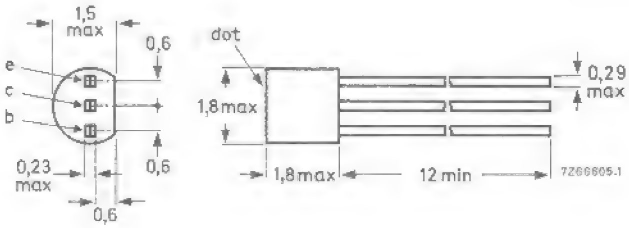
QUICK REFERENCE DATA

			BC200/01	BC200/02	BC200/03	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	20	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	20	20	V
Collector current (d.c.)	$-I_C$	max.	50	50	50	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain $-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V	h_{FE}	>	50	85	165	
		<	105	200	400	
Noise figure at R_S = 2 kΩ $-I_C$ = 0,2 mA; $-V_{CE}$ = 5 V Bandiwtdh: f = 30 Hz to 15 kHz	F	typ.	2	1,5	2	dB
		<	–	4,0	–	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-42.



Coloured dot on top of the black body indicates h_{FE} group:

BC200/01	red
BC200/02	yellow
BC200/03	green

The flat side is blue to distinguish from BC146.

MOUNTING INSTRUCTIONS

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1,5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	mW

Temperatures

Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	1,6	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

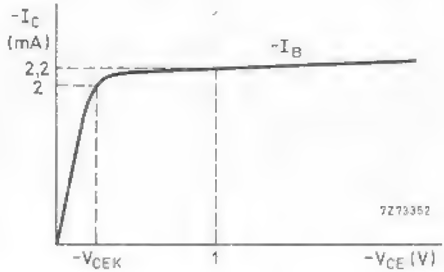
I_E = 0; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	100	nA
I_E = 0; $-V_{CB}$ = 20 V; T_j = 125 °C	$-I_{CBO}$	<	1	μA

Base-emitter voltage

$-I_C$ = 0.2 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	typ.	580	mV
$-I_C$ = 2 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	typ.	650	mV

Knee voltage

$-I_C$ = 2 mA; $-I_B$ = value for which $-I_C$ = 2,2 mA at $-V_{CE}$ = 1 V	$-V_{CEK}$	typ.	200	mV



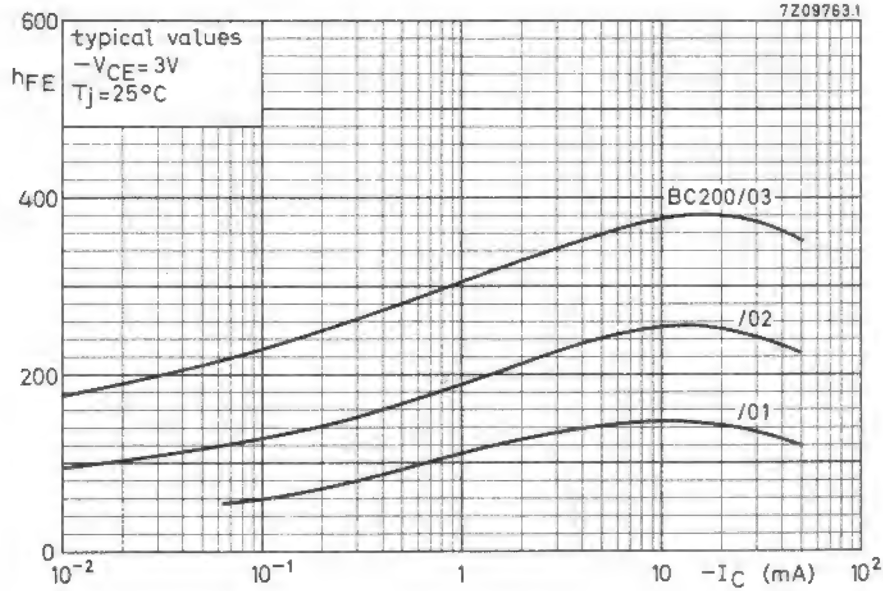
Collector capacitance at f = 1 MHz

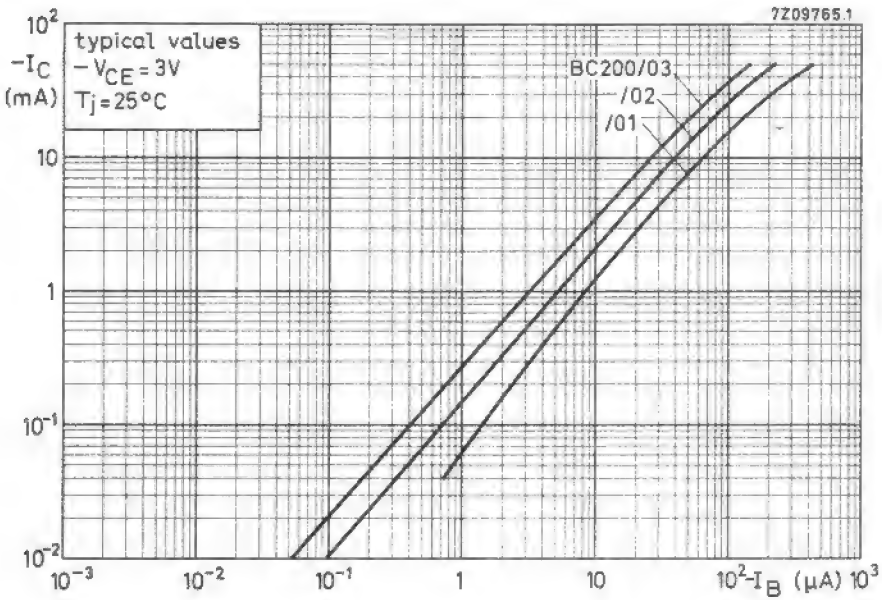
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	5	pF

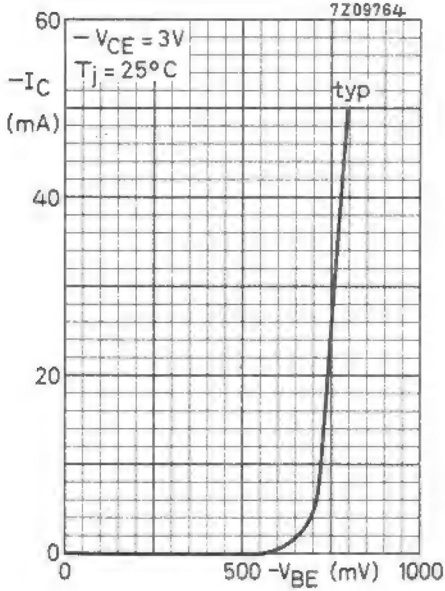
Transition frequency at f = 100 MHz

$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	f_T	typ.	90	MHz

D.C. current gain	BC200	/01	/02	/03	
$-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V	h_{FE}	typ. 75	140	250	
		50 to 105	85 to 200	165 to 400	
$-I_C$ = 2 mA; $-V_{CE}$ = 1 V	h_{FE}	> 60	100	175	
h parameters at f = 1 kHz					
$-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V					
Input impedance	h_{ie}	typ. 12	15	20	kΩ
Reverse voltage transfer ratio	h_{re}	typ. 13	25	40	10^{-4}
Small-signal current gain	h_{fe}	typ. 75	140	250	
Output admittance	h_{oe}	typ. 13	18	33	$\mu\Omega^{-1}$
Noise figure					
$-I_C$ = 0,2 mA; $-V_{CE}$ = 5 V; R_S = 2 kΩ; Bandwidth: f = 30 Hz to 15 kHz	F	typ. 2	1.5	2	dB
		< –	4	–	dB


7Z09763.1
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
h_{FE}
600
400
200
0
BC200/03
/02
/01
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09765.1
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
$-I_C$
(mA)
10^2
10
1
10^{-1}
10^{-2}
BC200/03
/02
/01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (μA)
10^3



7Z09764
60
40
20
0
$-I_C$
(mA)
$-V_{CE} = 3V$
$T_j = 25°C$
typ
0
500
$-V_{BE}$ (mV)
1000

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 variant envelopes, primarily intended for use in driver and output stages of audio amplifiers.

The BC327, BC327A, BC328 are complementary to the BC337, BC337A and BC338 respectively.

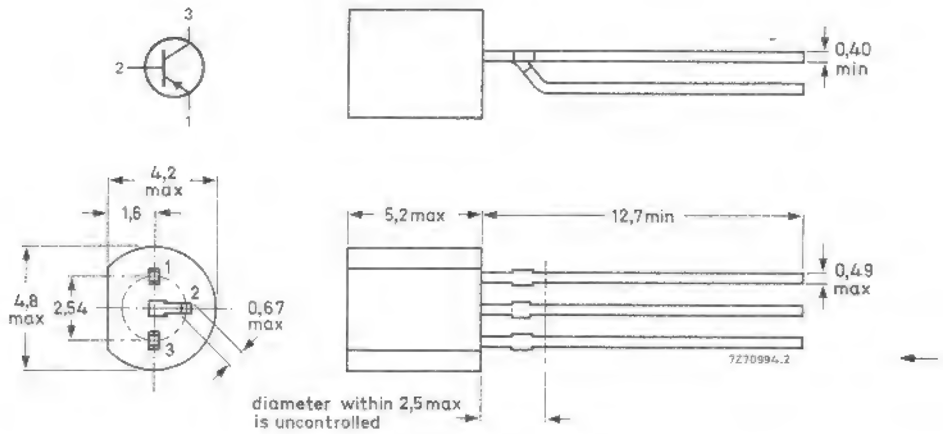
QUICK REFERENCE DATA

			BC327	BC327A	BC328	
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	50	60	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	25	V
Collector current (peak value)	$-I_{CM}$	max.		1000		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		800		mW
Junction temperature	T_j	max.		150		°C
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.		100		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC327	BC327A	BC328	
Collector-emitter voltage ($V_{BE} = 0$)	$-V_{CES}$	max.	50	60	30	V
Collector-emitter voltage (open base) $-I_C = 10$ mA	$-V_{CEO}$	max.	45	60	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		500		mA
Collector current (peak value)	$-I_{CM}$	max.		1000		mA
Emitter current (peak value)	I_{EM}	max.		1000		mA
Base current (d.c.)	$-I_B$	max.		100		mA
Base current (peak value)	$-I_{BM}$	max.		200		mA
Total power dissipation at $T_{amb} = 25$ °C	P_{tot}	max.		625		mW
up to $T_{amb} = 25$ °C	P_{tot}	max.		800		mW*
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,2	K/mW
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,156	K/mW*

* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 25$ °C	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 150$ °C	$-I_{CBO}$	<	5	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base emitter voltage*				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2	V
Saturation voltage				
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	700	mV
D.C. current gain				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}	>	40	
$-I_C = 100$ mA; $-V_{CE} = 1$ V; BC327; BC328	h_{FE}		100 to 600	
BC327A	h_{FE}		100 to 400	
BC327-16, BC328-16	h_{FE}		100 to 250	
BC327-25, BC328-25	h_{FE}		160 to 400	
BC327-40, BC328-40	h_{FE}		250 to 600	
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	100	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	8	pF
D.C. current gain ratio of matched pairs BC327/BC337; BC328/BC338				
$\lvert I_C \rvert = 100$ mA; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	typ.	1,25	
		<	1,40	

* $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

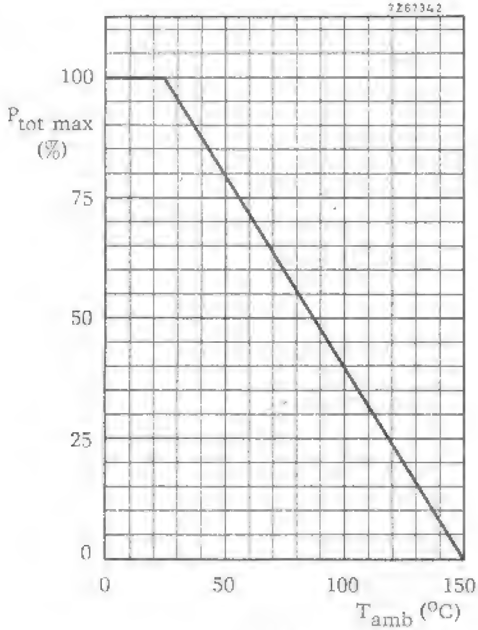

7Z67342
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

Fig. 2.

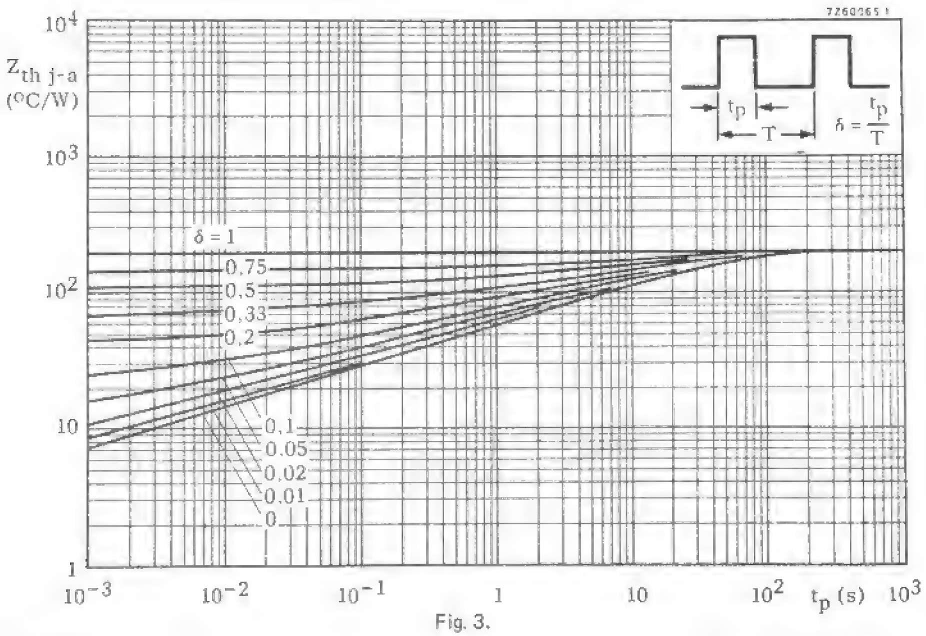

10^4
$Z_{th\ j\text{-}a}$
(°C/W)
10^3
$\delta = 1$
0.75
0.5
0.33
0.2
10^2
0.1
0.05
0.02
0.01
0
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 3.

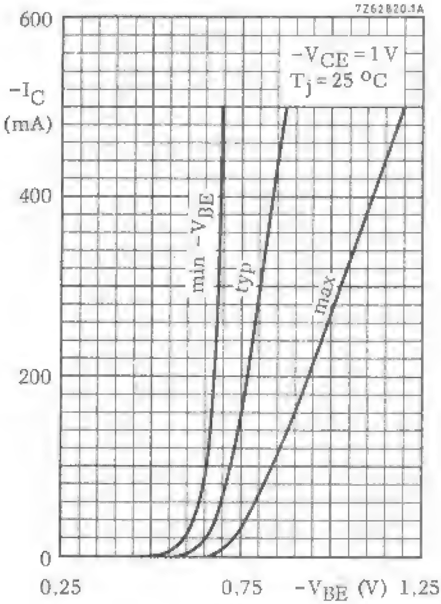


Fig. 4.

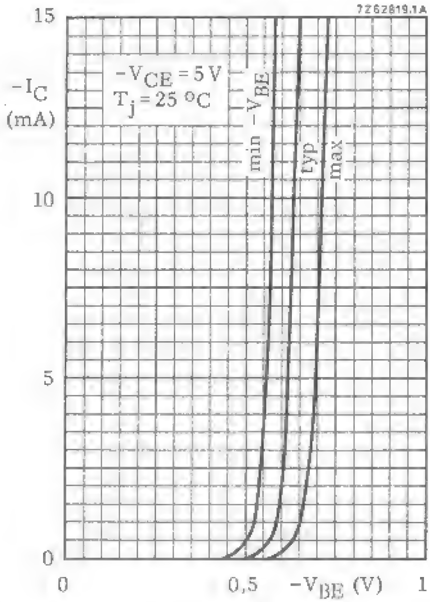


Fig. 5.

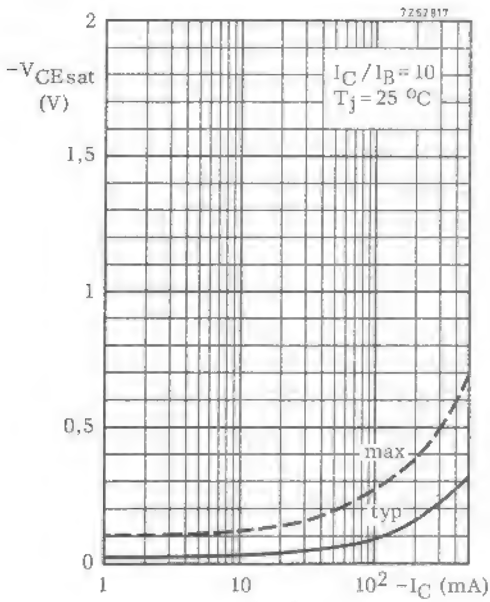


Fig. 6.

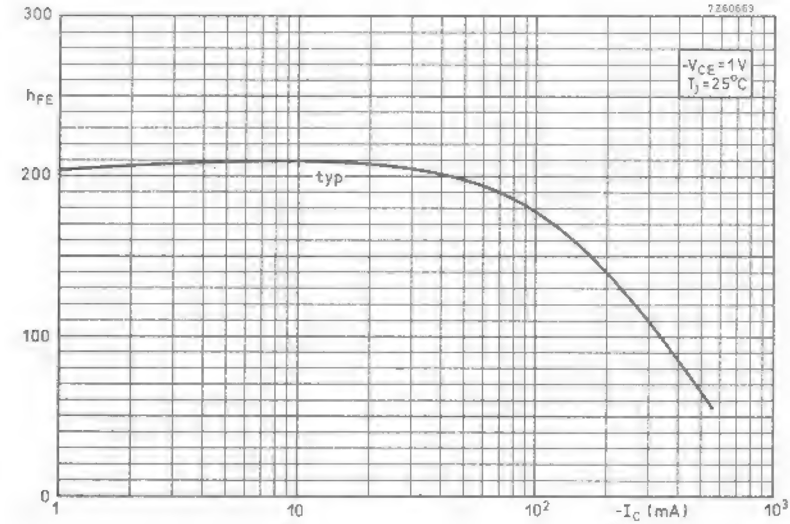

7Z60669
$-V_{CE} = 1\,V$
$T_j = 25\,^{\circ}C$
h_{FE}
300
200
100
0
1
10
10^2
10^3
$-I_C$ (mA)
typ

Fig. 7.

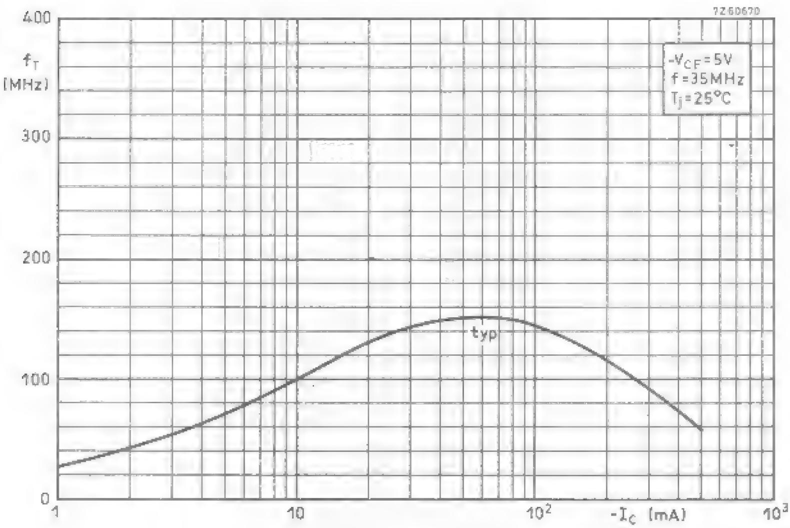

7Z60670
$-V_{CE} = 5\,V$
f = 35 MHz
$T_j = 25\,^{\circ}C$
f_T
(MHz)
400
300
200
100
0
1
10
10^2
10^3
$-I_C$ (mA)
typ

Fig. 8.

APPLICATION INFORMATION

2,8 W transformerless audio-frequency amplifier with matched pair BC328/BC338 in complementary class-B output stage up to T_{amb} = 45 °C.

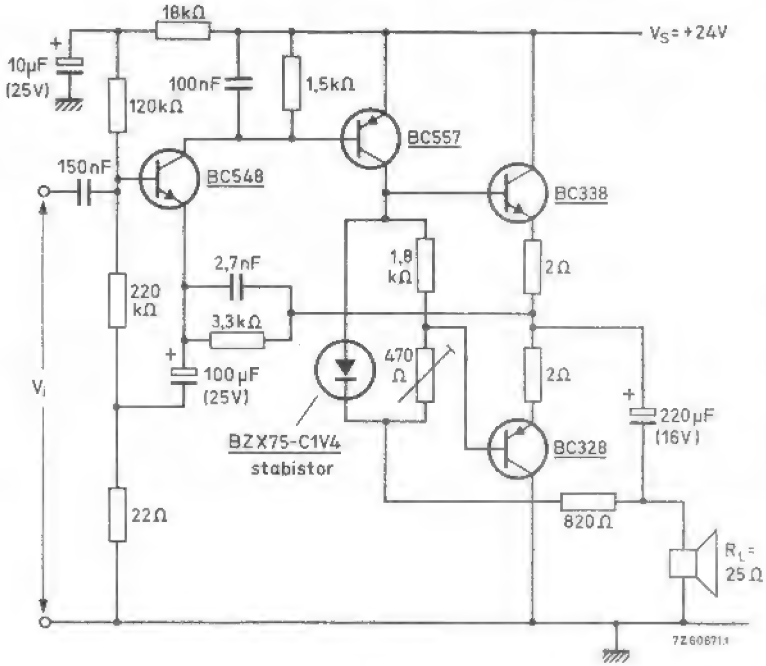


Fig. 9.

Performance at V_S = 24 V; R_L = 25 Ω

Collector quiescent current of BC338	I_{CQ}	typ.	1 mA
Input voltage for P_L = 50 mW	V_i	typ.	8 mV
Input voltage for P_L = 2,8 W	V_i	typ.	67 mV
Output power at f = 1 kHz; d_{tot} = 10%	P_L	typ.	2,8 W
Frequency response (3 dB)			70 to 16 000 Hz

This amplifier needs no external cooling fin, provided each output transistor is mounted with its leads not longer than 3 mm. The collector lead must, in addition, be soldered to a copper area of at least 10 mm x 10 mm.

APPLICATION INFORMATION (continued)

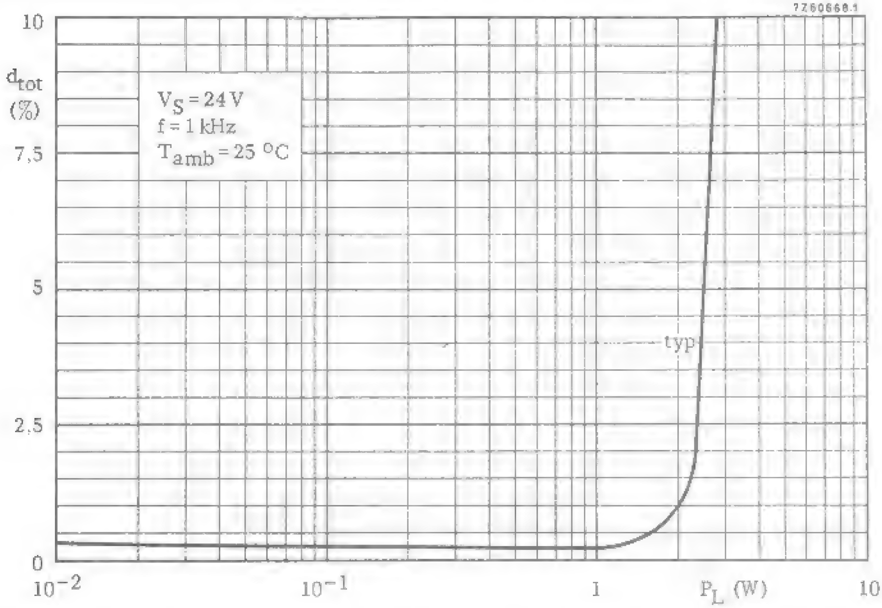


Fig. 10.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelopes, primarily intended for use in driver and output stages of audio amplifiers.

The BC337, BC337A, BC338 are complementary to the BC327, BC327A and BC328 respectively.

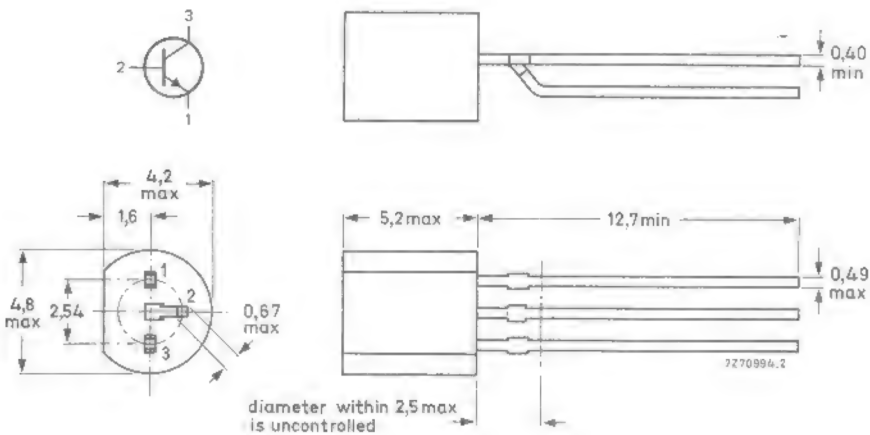
QUICK REFERENCE DATA

			BC337	BC337A	BC338	
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	50	60	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	25	V
Collector current (peak value)	I_{CM}	max.		1000		mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.		800		mW
Junction temperature	T_j	max.		150		^oC
Transition frequency at f = 35 MHz $I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.		100		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC337	BC337A	BC338	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	60	30	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	45	60	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		500		mA
Collector current (peak value)	I_{CM}	max.		1000		mA
Emitter current (peak value)	$-I_{EM}$	max.		1000		mA
Base current (d.c.)	I_B	max.		100		mA
Base current (peak value)	I_{BM}	max.		200		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.		625		mW
up to T_{amb} = 25 °C	P_{tot}	max.		800		mW*
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,2	K/mW
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,156	K/mW*

* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 25$ °C	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	5 µA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 µA
Base emitter voltage*			
$I_C = 500$ mA; $V_{CE} = 1$ V	V_{BE}	<	1,2 V
Saturation voltage			
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	700 mV
D.C. current gain			
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	40
$I_C = 100$ mA; $V_{CE} = 1$ V; BC337; BC338	h_{FE}		100 to 600
BC337A	h_{FE}		100 to 400
BC337-16, BC338-16	h_{FE}		100 to 250
BC337-25, BC338-25	h_{FE}		160 to 400
BC337-40, BC338-40	h_{FE}		250 to 600
Transition frequency at f = 35 MHz			
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	200 MHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	5 pF
D.C. current gain ratio of matched pairs BC327/BC337; BC328/BC338			
$\lvert I_C \rvert = 100$ mA; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	typ.	1,25
		<	1,40

* V_{BE} decreases by about 2 mV/°C with increasing temperature.

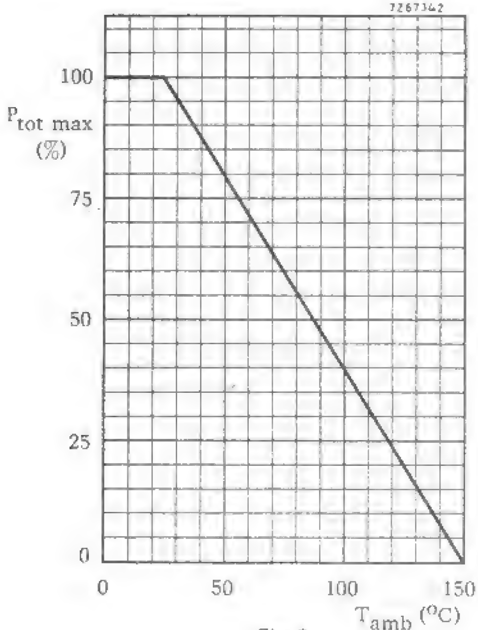

7267342
$P_{tot\ max}$ (%)
100
75
50
25
0
0
50
100
150
T_{amb} (°C)

Fig. 2.

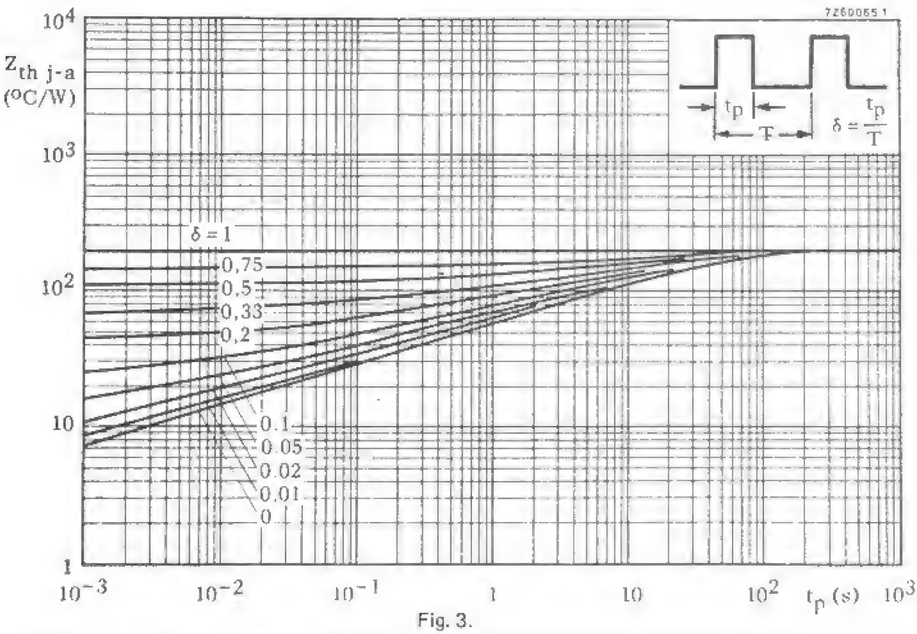

7260065.1
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
$\delta = 1$
0,75
0,5
0,33
0,2
0.1
0.05
0.02
0.01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3

Fig. 3.

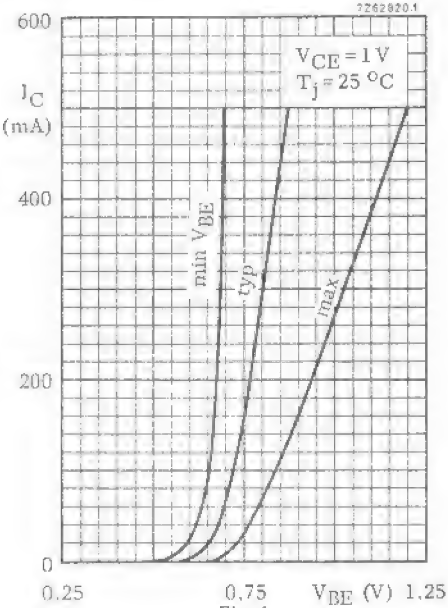


Fig. 4.

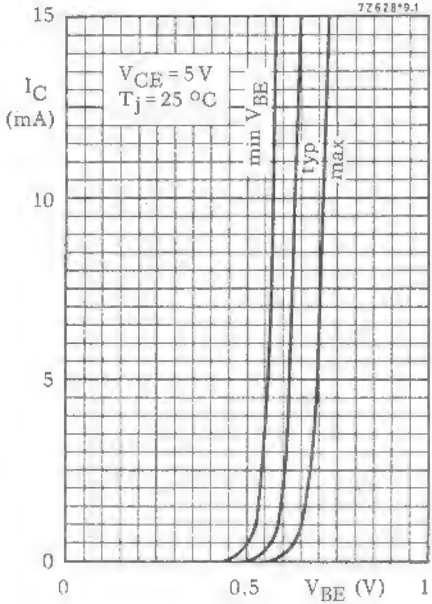


Fig. 5.

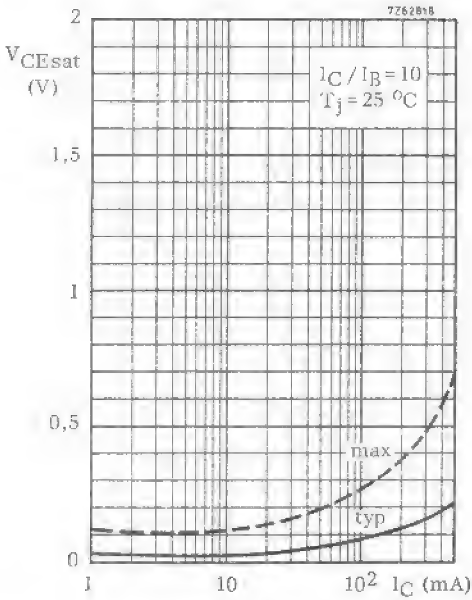


Fig. 6.

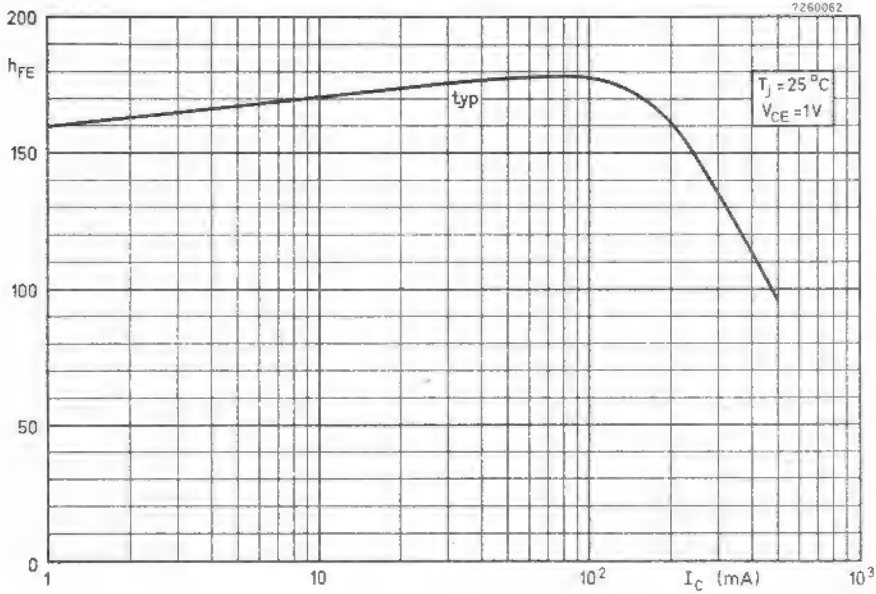


Fig. 7.

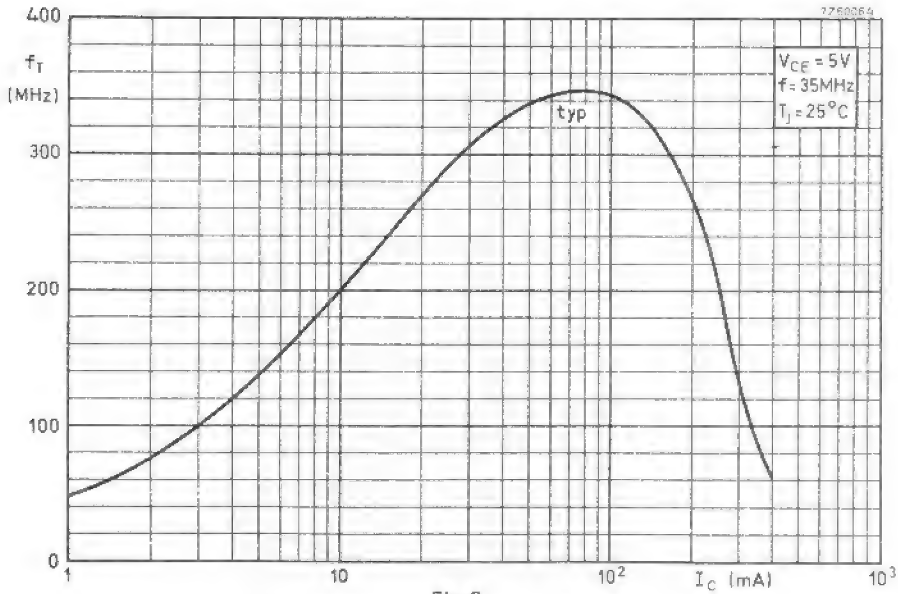


Fig. 8.

APPLICATION INFORMATION, see BC327; BC328.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B audio output stages up to 3 W.

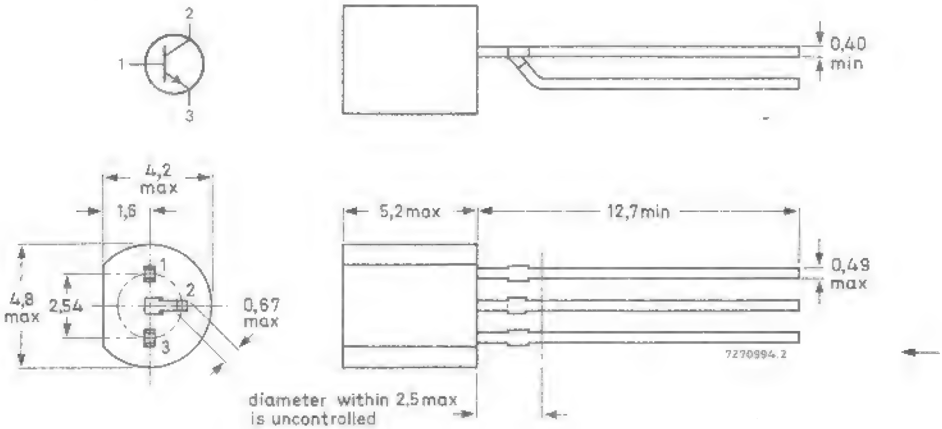
QUICK REFERENCE DATA

Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	^{o}C
D.C. current gain $I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}		85 to 375	
Transition frequency at f = 35 MHz $I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	25 V
Collector-emitter voltage (open base)	V_{CEO}	max.	20 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	1 A
Collector current (peak value)	I_{CM}	max.	2 A
Base current (d.c.)	I_B	max.	100 mA
Base current (peak value)	I_{BM}	max.	200 mA
Total power dissipation			
at T_{amb} = 25 °C (in free air)	P_{tot}	max.	0,8 W
up to T_{amb} = 25 °C*	P_{tot}	max.	1 W
Storage temperature	T_{stg}	−65 to + 150 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

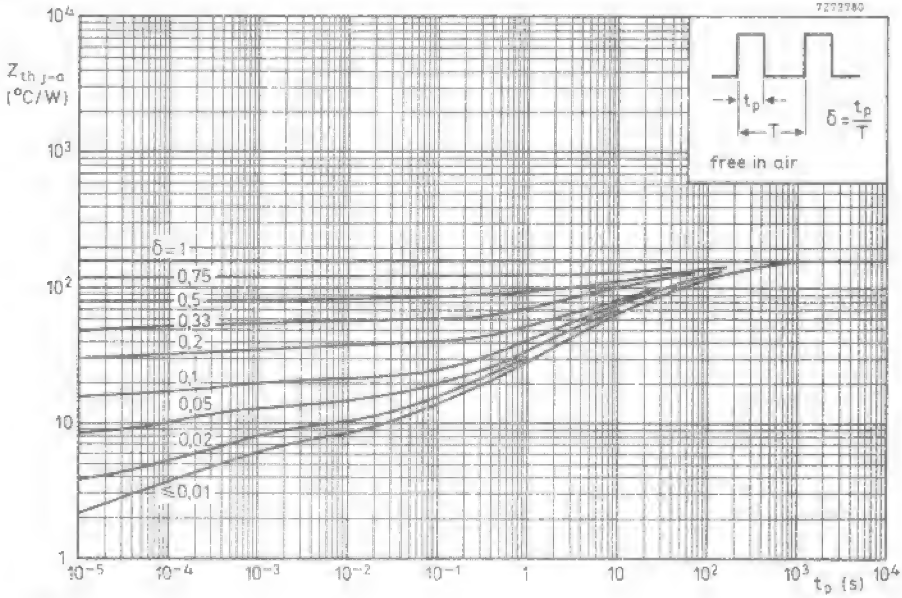
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	156 °C/W
From junction to ambient*	$R_{th\,j\text{-}a}$	=	125 °C/W
From junction to case	$R_{th\,j\text{-}c}$	=	60 °C/W

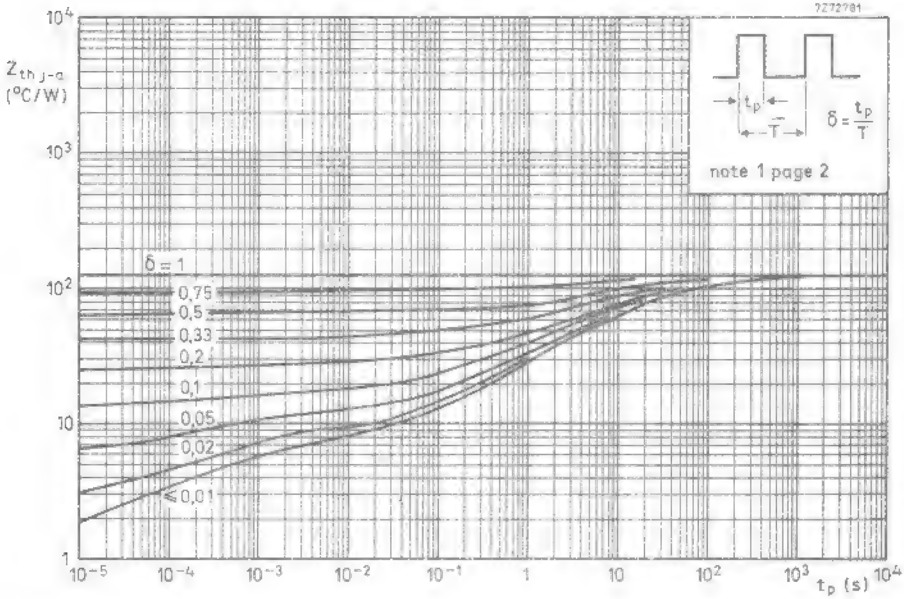
* Transistor mounted on printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

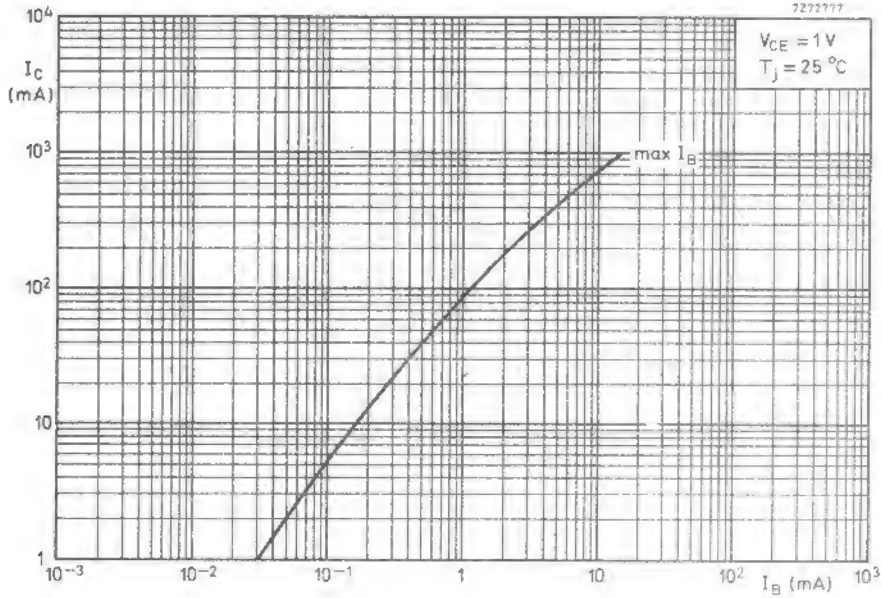
CHARACTERISTICS

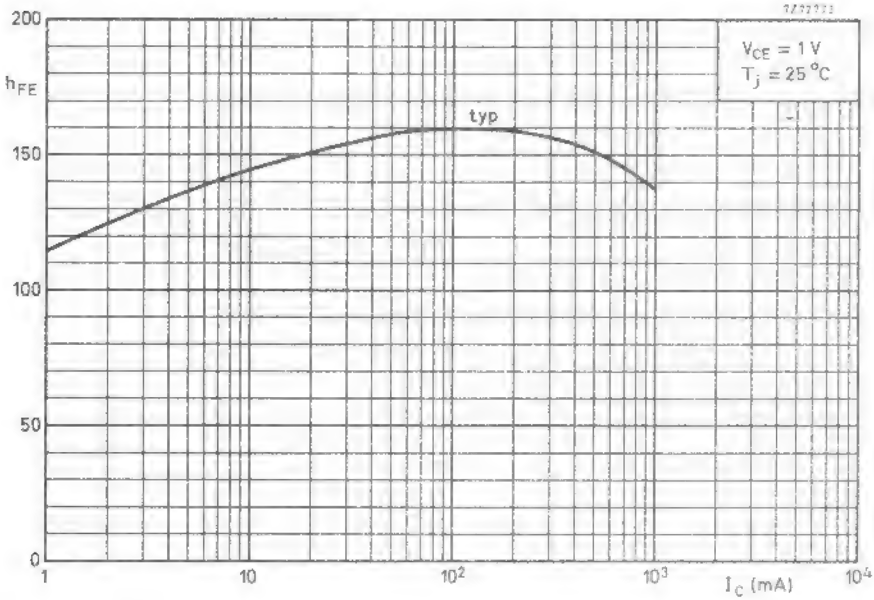
T_j = 25 °C unless otherwise specified

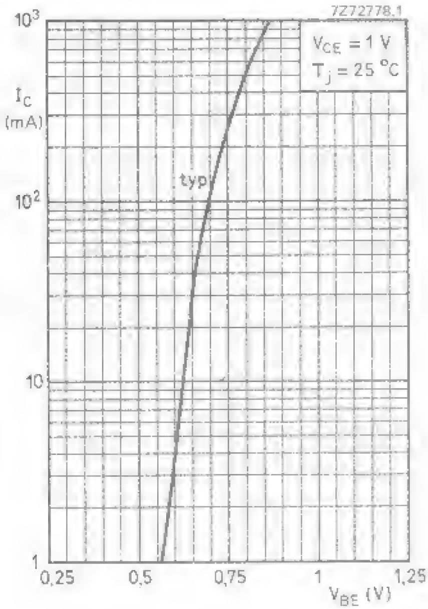
Collector cut-off current			
$I_E = 0$; $V_{CB} = 25$ V	I_{CBO}	<	10 μA
$I_E = 0$; $V_{CB} = 25$ V; $T_j = 150$ °C	I_{CBO}	<	1 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 μA
Base-emitter voltage			
$I_C = 5$ mA; $V_{CE} = 10$ V	V_{BE}	typ.	0,62 V
$I_C = 1$ A; $V_{CE} = 1$ V	V_{BE}	<	1 V
Collector-emitter saturation voltage			
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	0,5 V
D.C. current gain			
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{FE}	>	50
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}		85 to 375
$I_C = 1$ A; $V_{CE} = 1$ V	h_{FE}	>	60
Collector capacitance at f = 450 kHz			
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	27 pF
Cut-off frequency			
$I_C = 10$ mA; $V_{CE} = 5$ V	f_{hfe}	typ.	400 kHz
Transition frequency at f = 35 MHz			
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	60 MHz
D.C. current gain ratio of matched pair BC368/BC369			
$\|I_C\| = 500$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,4

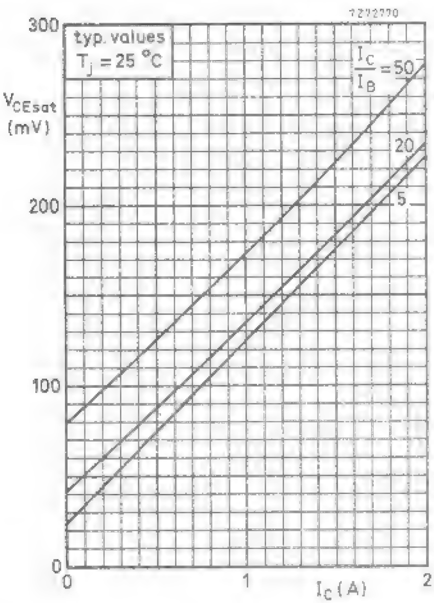

7Z72780
$Z_{th\ j-a}$
(°C/W)
$\delta = \frac{t_p}{T}$
t_p
T
free in air
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p (s)

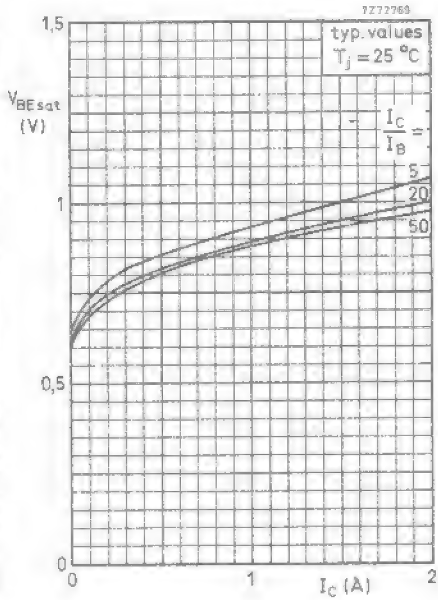

7Z72781
$Z_{th\ j-a}$
(°C/W)
$\delta = \frac{t_p}{T}$
t_p
T
note 1 page 2
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p (s)

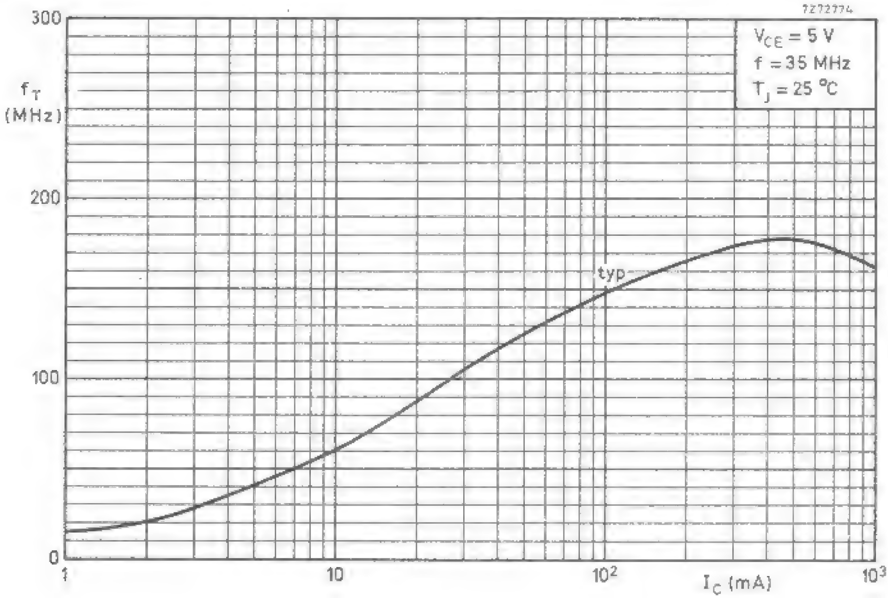

7Z72777
10^4
I_C (mA)
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3
V_{CE} = 1 V
T_j = 25 °C
max I_B


200
h_{FE}
150
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4
V_{CE} = 1 V
T_j = 25 °C
typ


7Z72778.1
$V_{CE} = 1$ V
$T_j = 25$ °C
I_C (mA)
typ
10^3
10^2
10
1
0,25
0,5
0,75
1
1,25
V_{BE} (V)


7Z72770
typ. values
$T_j = 25$ °C
$\frac{I_C}{I_B} = 50$
20
5
V_{CEsat} (mV)
300
200
100
0
0
1
2
I_C (A)


7Z72769
typ. values
$T_j = 25$ °C
$\frac{I_C}{I_B} =$
5
20
50
V_{BEsat} (V)
1,5
1
0,5
0
0
1
2
I_C (A)


7Z72774
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
f_T (MHz)
300
200
100
0
typ
1
10
10^2
10^3
I_C (mA)

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B output stages up to 3 W.

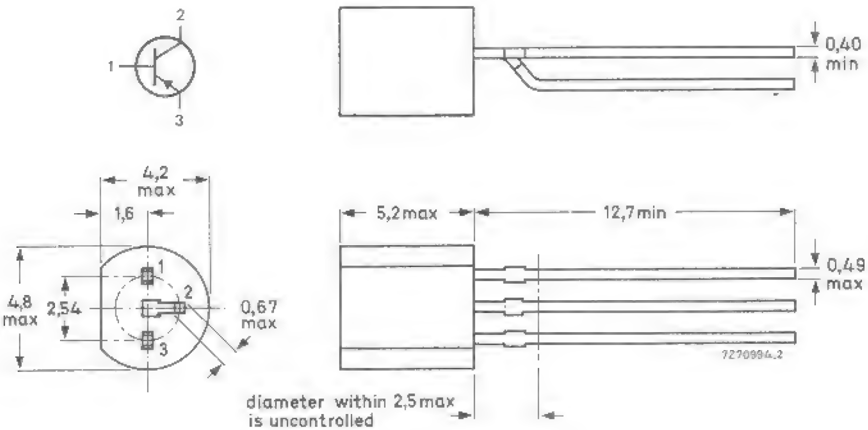
QUICK REFERENCE DATA

Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	2	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-emitter voltage ($V_{BE} = 0$)	$-V_{CES}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Collector current (d.c.)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	2	A
Base current (d.c.)	$-I_B$	max.	100	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA
Total power dissipation				
at $T_{amb} = 25\ ^oC$ (in free air)	P_{tot}	max.	0,8	W
up to $T_{amb} = 25\ ^oC$*	P_{tot}	max.	1	W
Storage temperature	T_{stg}	−65 to + 150		^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

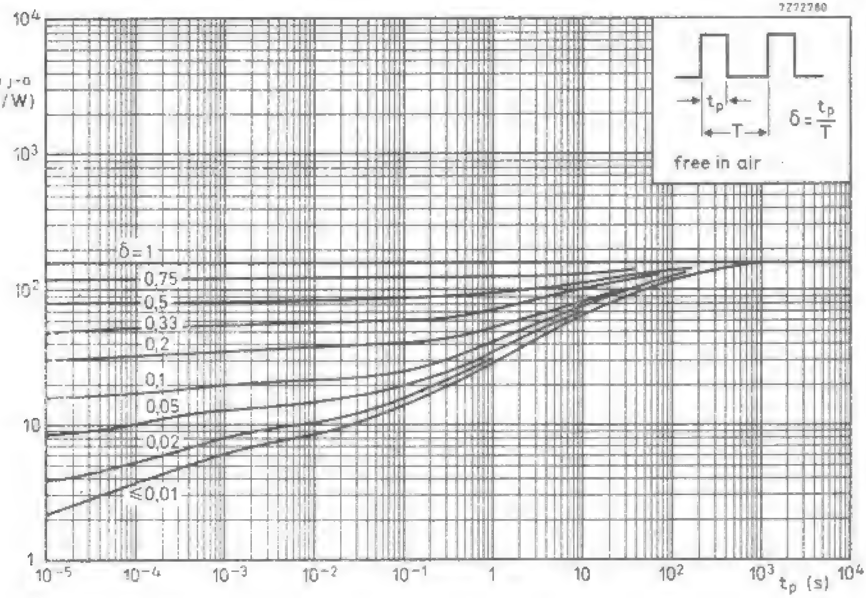
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	$^oC/W$
From junction to ambient*	$R_{th\ j\text{-}a}$	=	125	$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$	=	60	$^oC/W$

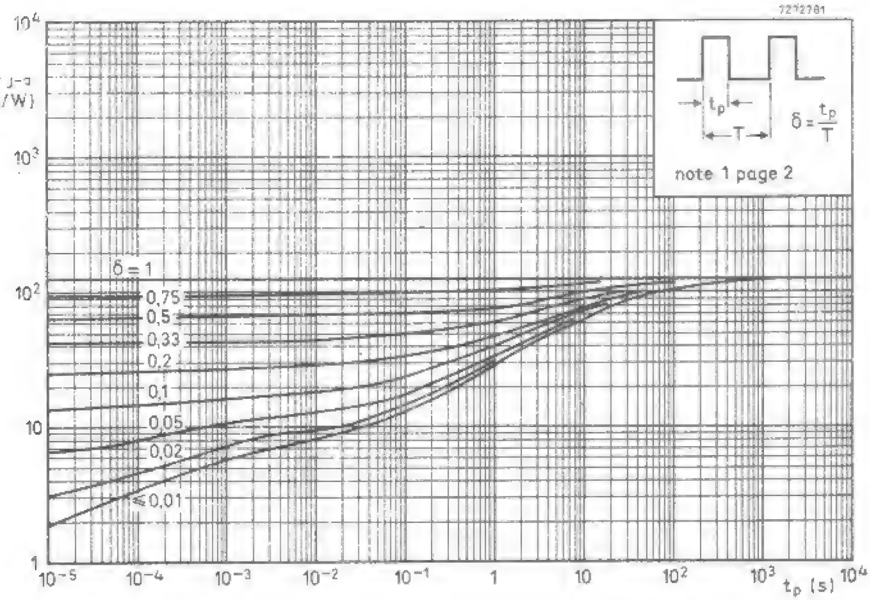
* Transistor mounted on printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

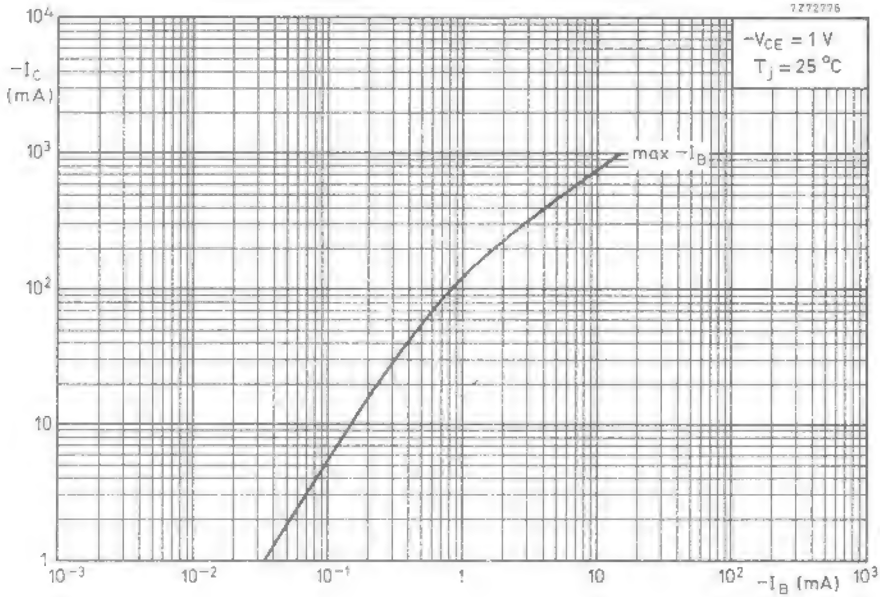
CHARACTERISTICS

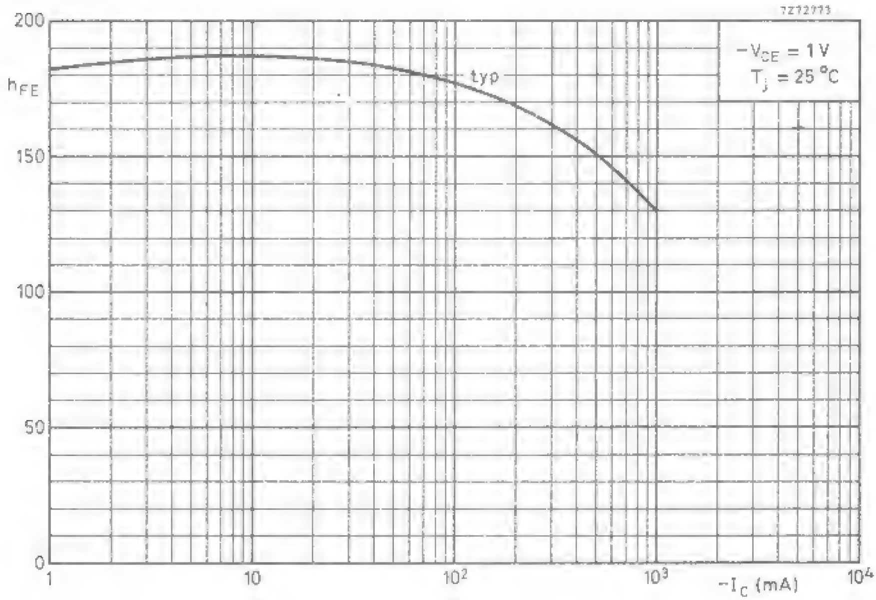
T_j = 25 °C unless otherwise specified

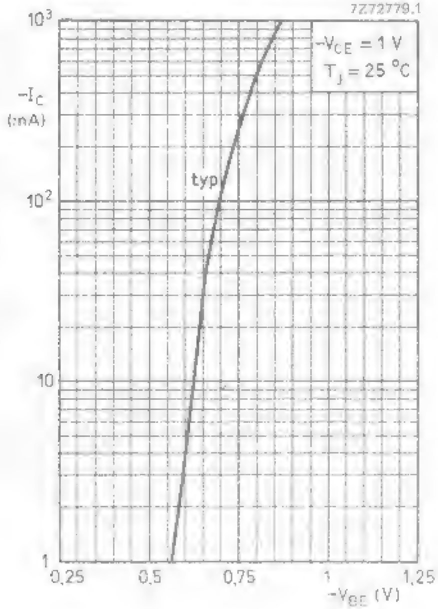
Collector cut-off current			
$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	<	10 μA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base-emitter voltage			
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,62 V
$-I_C = 1$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1 V
Collector-emitter saturation voltage			
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	0,5 V
D.C. current gain			
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}		85 to 375
$-I_C = 1$ A; $-V_{CE} = 1$ V	h_{FE}	>	60
Collector capacitance at f = 450 kHz			
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	45 pF
Cut-off frequency			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_{hfe}	typ.	350 kHz
Transition frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	60 MHz
D.C. current gain ratio of matched pair BC368/BC369			
$\lvert I_C \rvert = 500$ mA; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	<	1,4

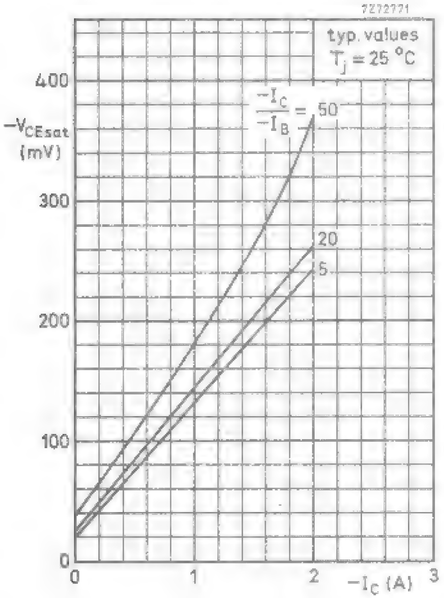

7Z72780
$Z_{th\ j-a}$ (°C/W)
free in air
$\delta = \frac{t_p}{T}$
t_p
T
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

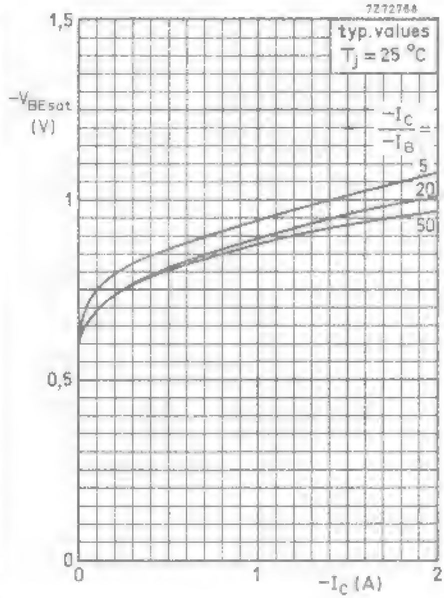

7Z72781
$Z_{th\ j-a}$ (°C/W)
note 1 page 2
$\delta = \frac{t_p}{T}$
t_p
T
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

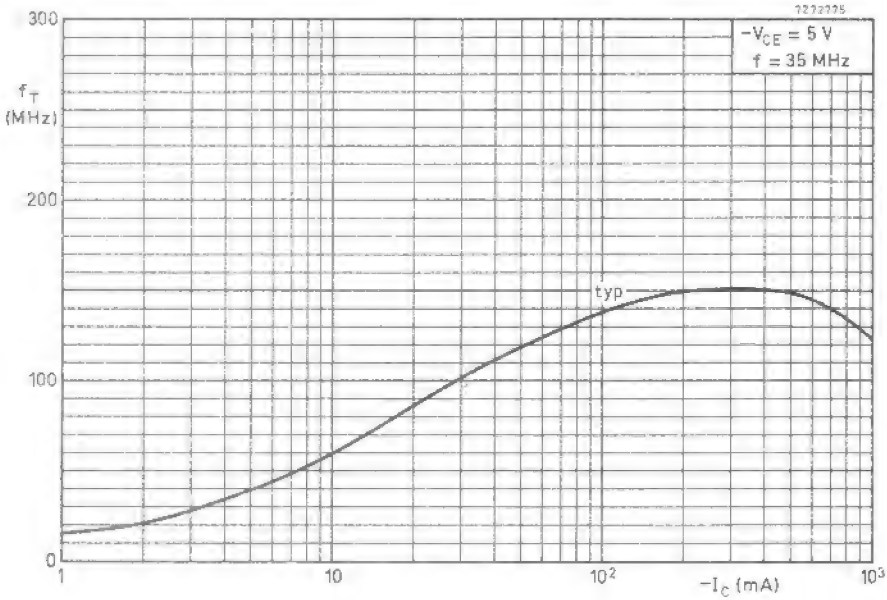

7Z72776
$-V_{CE}$ = 1 V
T_j = 25 °C
$-I_C$ (mA)
10^4
10^3
10^2
10
1
max $-I_B$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z72773
$-V_{CE}$ = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
1
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z72779.1
10^3
$-I_C$ (mA)
10^2
10
1
0,25
0,5
0,75
1
1,25
$-V_{BE}$ (V)
$-V_{CE} = 1$ V
$T_j = 25$ °C
typ


7Z72771
typ. values
$T_j = 25$ °C
$-V_{CEsat}$ (mV)
400
300
200
100
0
$\frac{-I_C}{-I_B} =$ 50
20
5
0
1
2
3
$-I_C$ (A)


7Z72768
typ. values
$T_j = 25$ °C
$-V_{BEsat}$ (V)
1,5
1
0,5
0
$\frac{-I_C}{-I_B} =$
5
20
50
0
1
2
$-I_C$ (A)


7Z72775
$-V_{CE}$ = 5 V
f = 35 MHz
f_T
(MHz)
300
200
100
0
typ
1
10
10^2
$-I_C$ (mA)
10^3

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC375/BC376 is the matched complementary pair suitable for output stages up to 2 W.

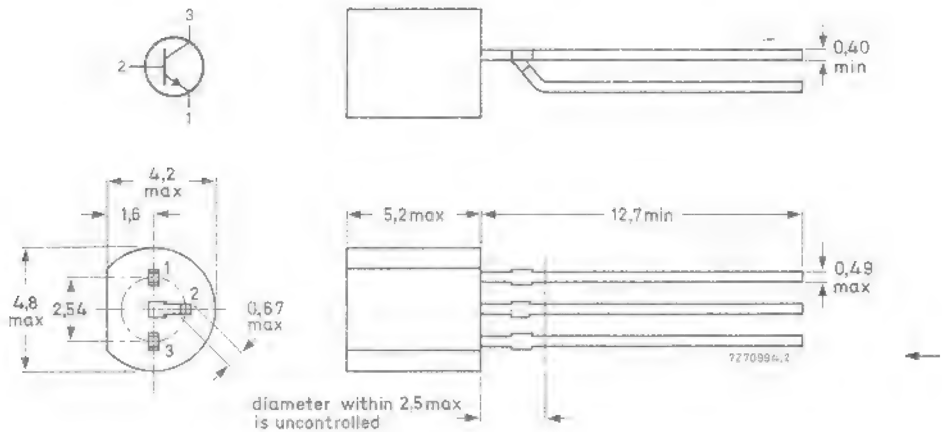
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	1,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 150 mA; V_{CE} = 1 V	h_{FE}		60 to 340	
Transition frequency at f = 35 MHz I_C = 150 mA; V_{CE} = 1 V	f_T	typ.	150	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	25 V
Collector-emitter voltage (open base)	V_{CEO}	max.	20 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	1 A
Collector current (peak value)	I_{CM}	max.	1,5 A
Base current (d.c.)	I_B	max.	100 mA
Base current (peak value)	I_{BM}	max.	200 mA
Total power dissipation			
at T_{amb} = 25 °C (in free air)	P_{tot}	max.	625 mW
up to T_{amb} = 25 °C*	P_{tot}	max.	800 mW
Storage temperature	T_{stg}		−65 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200 K/W
From junction to ambient *	$R_{th\ j\text{-}a}$	=	156 K/W
From junction to case	$R_{th\ j\text{-}c}$	=	95 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; V_{CB} = 20 V	I_{CBO}	<	100 nA
$I_E = 0$; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	5 μA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	10 μA
Base-emitter voltage**			
I_C = 5 mA; V_{CE} = 10 V	V_{BE}	typ.	650 mV
I_C = 700 mA; V_{CE} = 1 V	V_{BE}	<	1000 mV
Collector-emitter saturation voltage			
I_C = 700 mA; I_B = 70 mA	V_{CEsat}	typ.	250 mV
		<	500 mV
D.C. current gain			
I_C = 5 mA; V_{CE} = 10 V	h_{FE}	>	55
I_C = 150 mA; V_{CE} = 1 V	h_{FE}		60 to 340
I_C = 700 mA; V_{CE} = 1 V	h_{FE}	>	35
Transition frequency at f = 35 MHz			
I_C = 150 mA; V_{CE} = 1 V	f_T	typ.	150 MHz
D.C. current gain ratio of matched pair BC375/BC376			
$\lvert I_C\rvert$ = 150 mA; $\lvert V_{CE}\rvert$ = 1 V	h_{FE1}/h_{FE2}	<	2

* Transistor mounted on printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

** V_{BE} decreases by about 2 mV/K with increasing temperature.

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC375/BC376 is the matched complementary pair suitable for output stages up to 2 W.

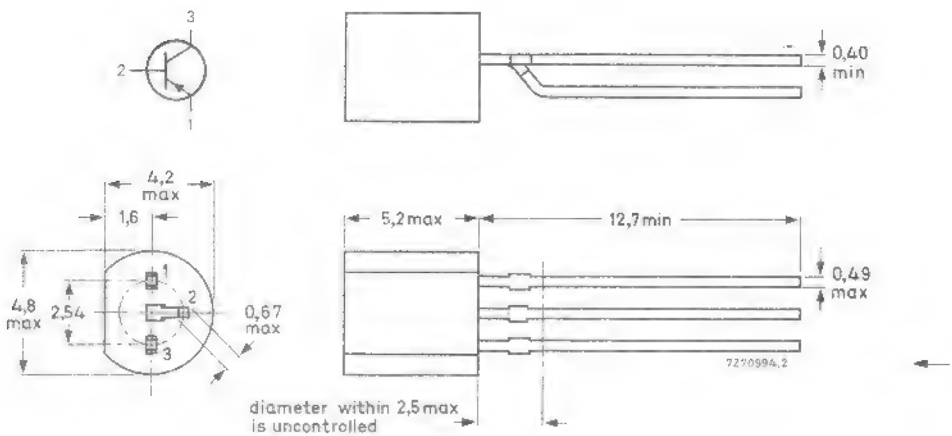
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Collector current (peak value)	$-I_{CM}$	max.	1,5 A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800 mW
Junction temperature	T_j	max.	150 °C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}		60 to 340
Transition frequency at f = 35 MHz $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	f_T	typ.	150 MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	1 A
Collector current (peak value)	$-I_{CM}$	max.	1,5 A
Base current (d.c.)	$-I_B$	max.	100 mA
Base current (peak value)	$-I_{BM}$	max.	200 mA
Total power dissipation			
at T_{amb} = 25 °C (in free air)	P_{tot}	max.	625 mW
up to T_{amb} = 25 °C*	P_{tot}	max.	800 mW
Storage temperature	T_{stg}	−65 to + 150 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200 K/W
From junction to ambient *	$R_{th\ j\text{-}a}$	=	156 K/W
From junction to case	$R_{th\ j\text{-}c}$		95 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	100 nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 150$ °C	$-I_{CBO}$	<	5 µA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 µA
Base-emitter voltage **			
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	typ.	650 mV
$-I_C$ = 700 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	<	1000 mV
Collector-emitter saturation voltage			
$-I_C$ = 700 mA; $-I_B$ = 70 mA	$-V_{CEsat}$	typ.	280 mV
		<	500 mV
D.C. current gain			
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	h_{FE}	>	55
$-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}		60 to 340
$-I_C$ = 700 mA; $-V_{CE}$ = 1 V	h_{FE}	>	35
Transition frequency at f = 35 MHz			
$-I_C$ = 150 mA; $-V_{CE}$ = 1 V	f_T	typ.	150 MHz
D.C. current gain ratio of matched pair BC375/BC376			
$\lvert I_C \rvert$ = 150 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	<	2

* Transistor mounted on printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

** $-V_{BE}$ decreases by about 2 mV/K with increasing temperature.

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in a plastic TO-92 variant, especially suitable for use in driver stages of audio amplifiers.

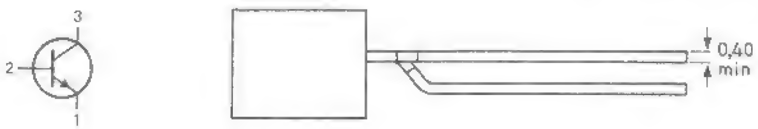
QUICK REFERENCE DATA

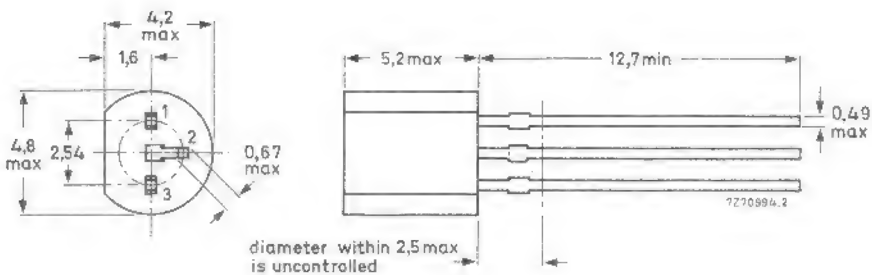
			BC546	BC547	BC548	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	65	45	30	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	500	mW
Junction temperature	T_j	max.	150	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	125	
		<	500	900	900	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			BC546	BC547	BC548	
Voltage						
Collector-base voltage (open emitter)	V_{CBO}	max.	80	50	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	65	45	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	5	V

Current

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW

Temperature

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 30\ V$	I_{CBO}	<	15	nA
$I_E = 0$; $V_{CB} = 30\ V$; $T_j = 150\ ^oC$	I_{CBO}	<	5	μA

Base-emitter voltage [1]

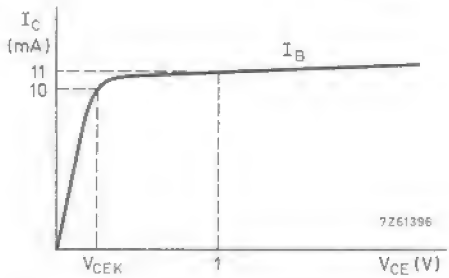
$I_C = 2\ mA$; $V_{CE} = 5\ V$	V_{BE}	typ.	660	mV
			580 to 700	mV
$I_C = 10\ mA$; $V_{CE} = 5\ V$	V_{BE}	<	770	mV

Saturation voltage [2]

$I_C = 10\ mA$; $I_B = 0.5\ mA$	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
$I_C = 100\ mA$; $I_B = 5\ mA$	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV

Knee voltage

$I_C = 10\ mA$; I_B = value for which $I_C = 11\ mA$ at $V_{CE} = 1\ V$	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 10\ V$	C_c	typ.	2,5	pF
		<	4,5	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; $V_{EB} = 0,5\ V$	C_e	typ.	9	pF

Transition frequency at f = 35 MHz

$I_C = 10\ mA$; $V_{CE} = 5\ V$	f_T	typ.	300	MHz

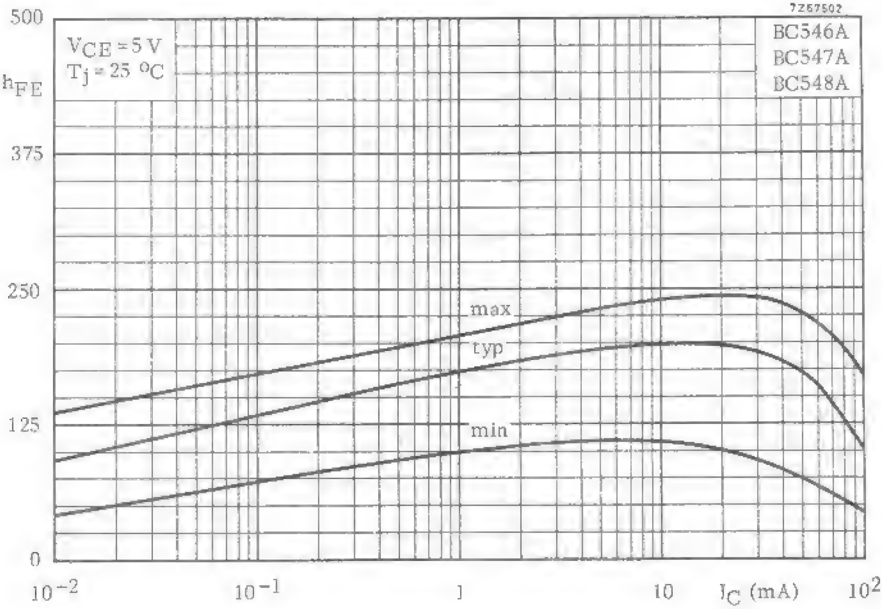
1) V_{BE} decreases by about 2 mV/^oC with increasing temperature.

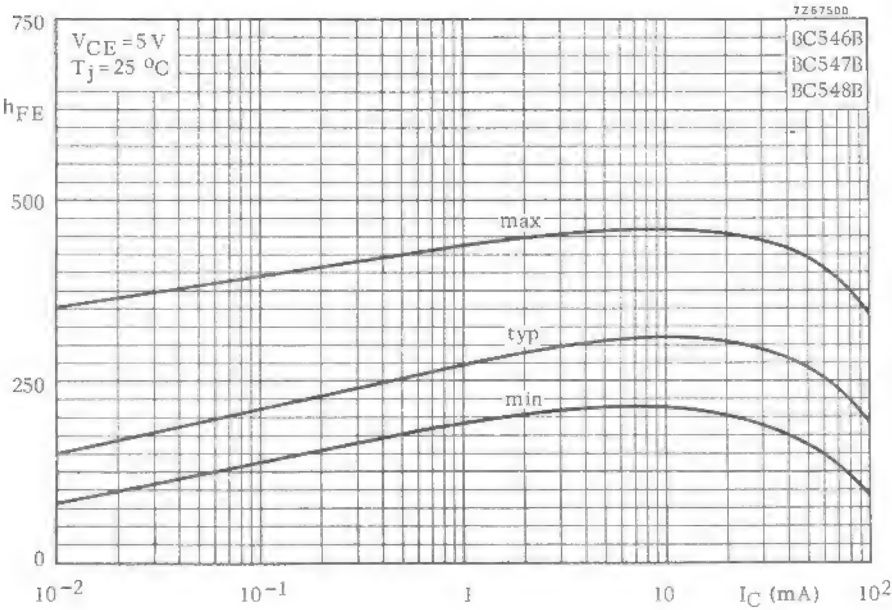
2) V_{BEsat} decreases by about 1,7 mV/^oC with increasing temperature.

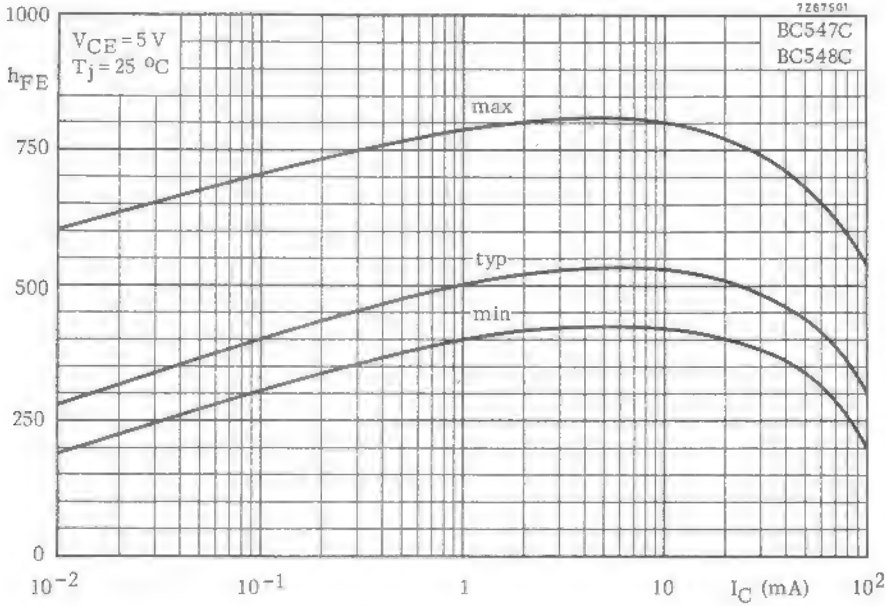
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

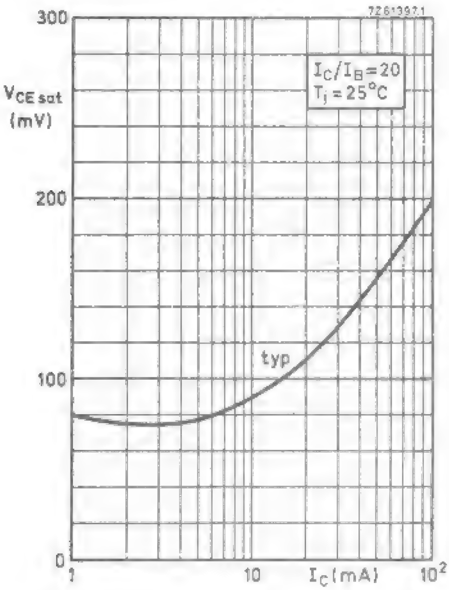
			BC546	BC547	BC548	
Small signal current gain at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	125	
		<	500	900	900	
Noise figure at R_S = 2 kΩ						
I_C = 200 μA; V_{CE} = 5 V						
f = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB
		<	10	10	10	dB

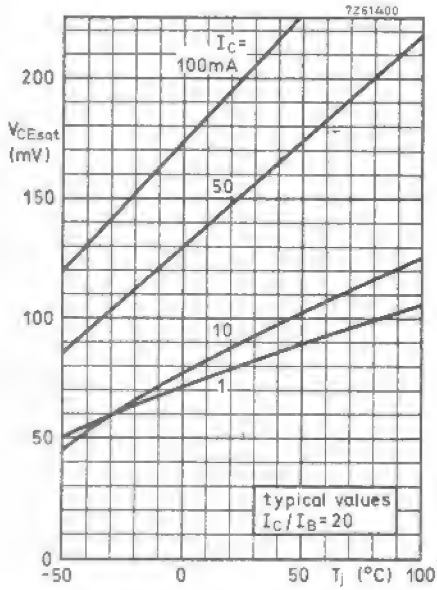
			BC546A BC547A BC548A	BC546B BC547B BC548B	BC547C BC548C
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270
		>	110	200	420
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520
		<	220	450	800

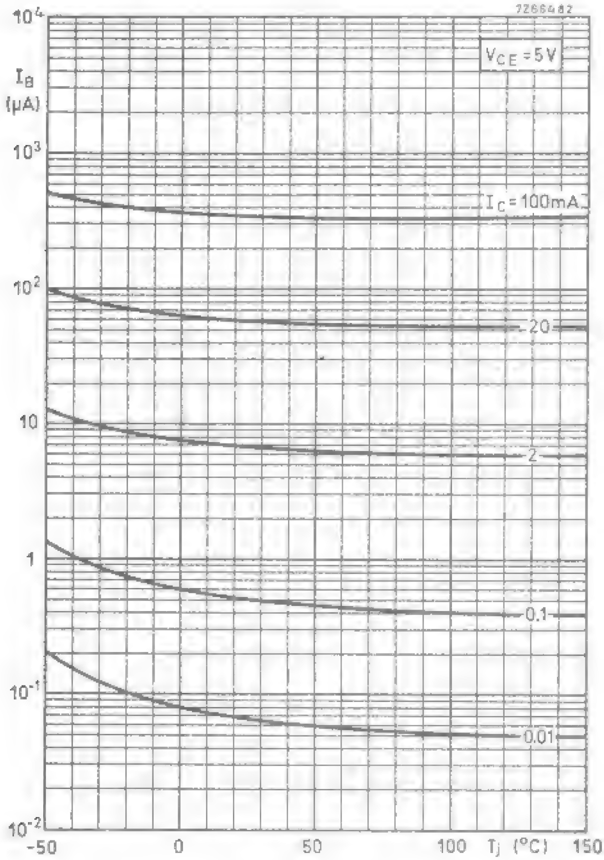

7Z67502
BC546A
BC547A
BC548A
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
500
375
250
125
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z67500
BC546B
BC547B
BC548B
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

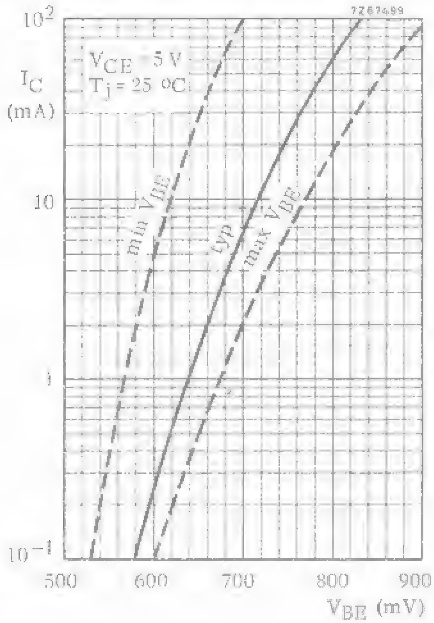

7Z67501
BC547C
BC548C
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
1000
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

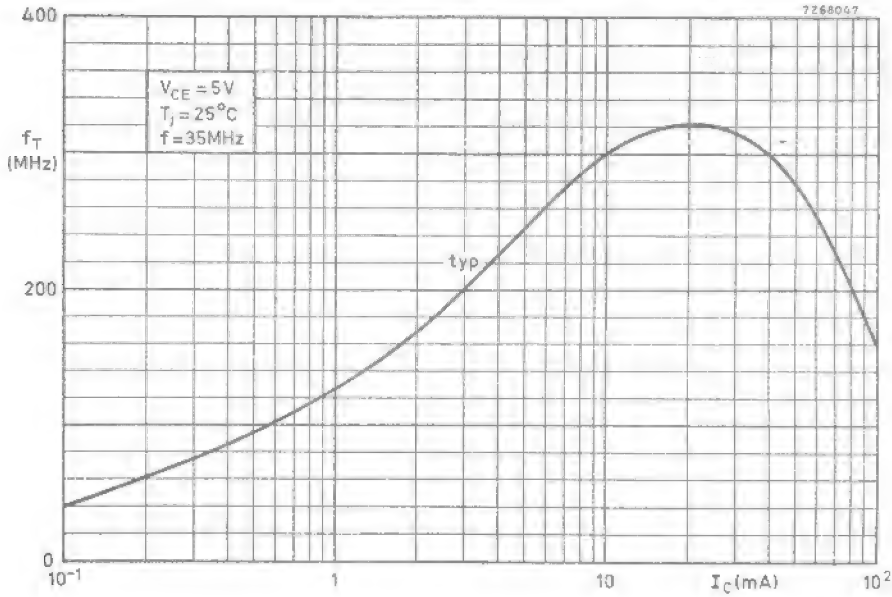

7Z61397.1
I_C/I_B = 20
T_j = 25 °C
$V_{CE\,sat}$ (mV)
300
200
100
0
typ
1
10
I_C (mA)
10^2

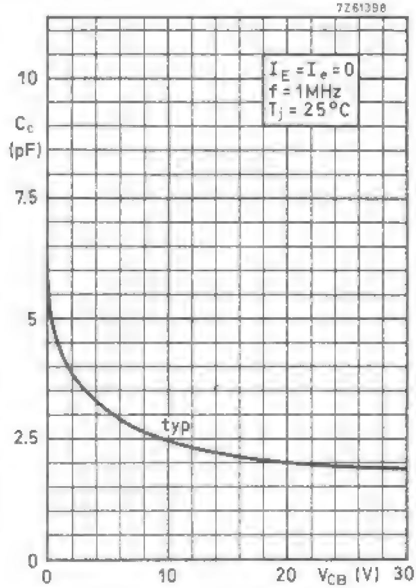

7Z61400
I_C = 100mA
50
10
1
V_{CEsat} (mV)
200
150
100
50
0
typical values
I_C/I_B = 20
−50
0
50
T_j (°C)
100

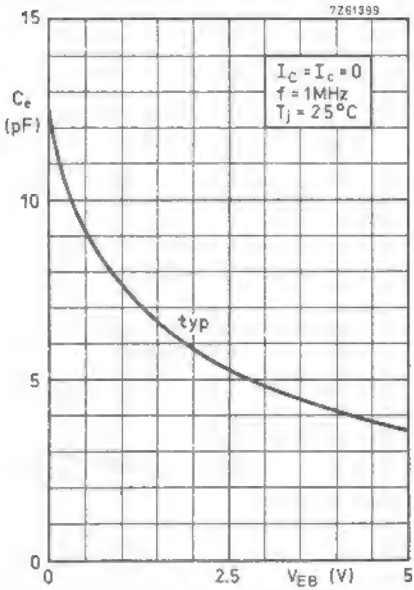


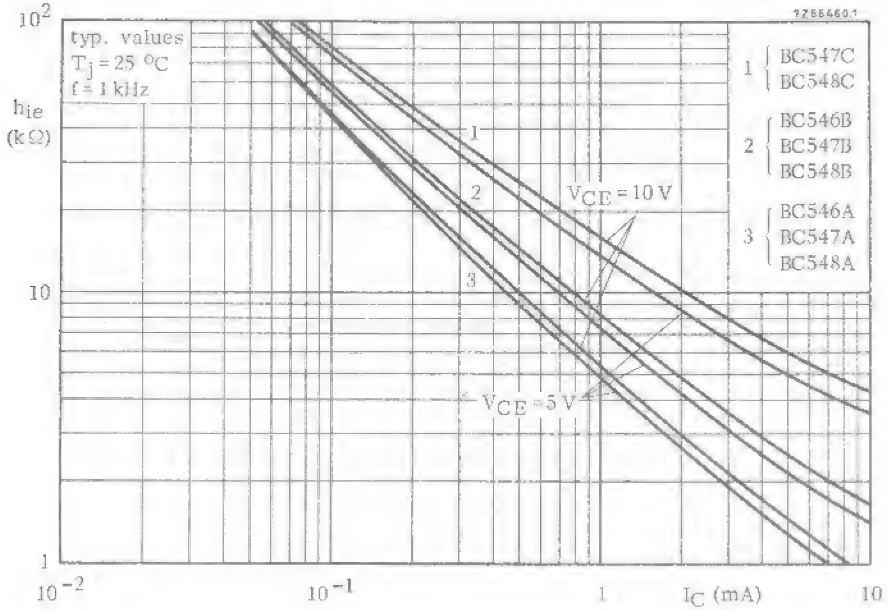
Typical behaviour of base current versus junction temperature

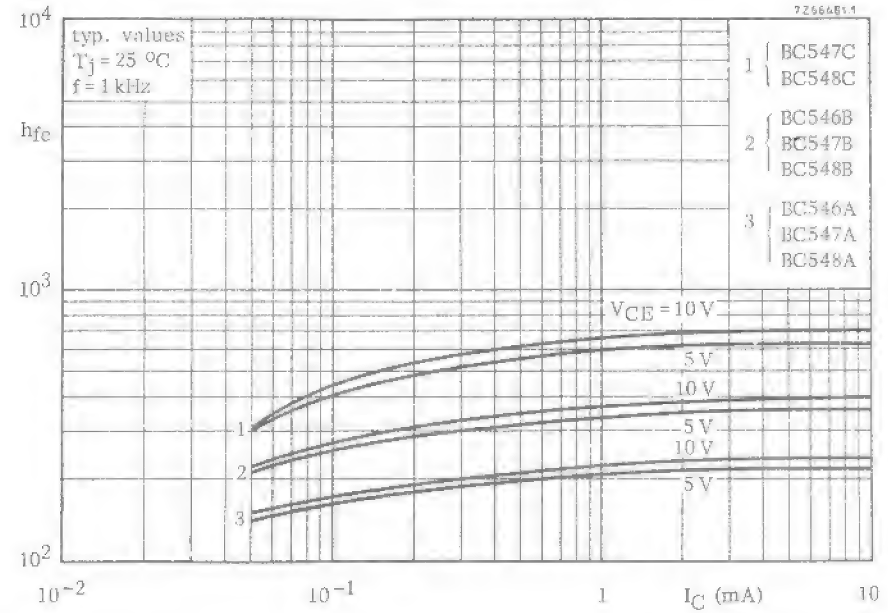

7Z67499
10^2
I_C
(mA)
$V_{CE} = 5$ V
$T_j = 25$ °C
10
min V_{BE}
typ
max V_{BE}
1
10^{-1}
500
600
700
800
900
V_{BE} (mV)

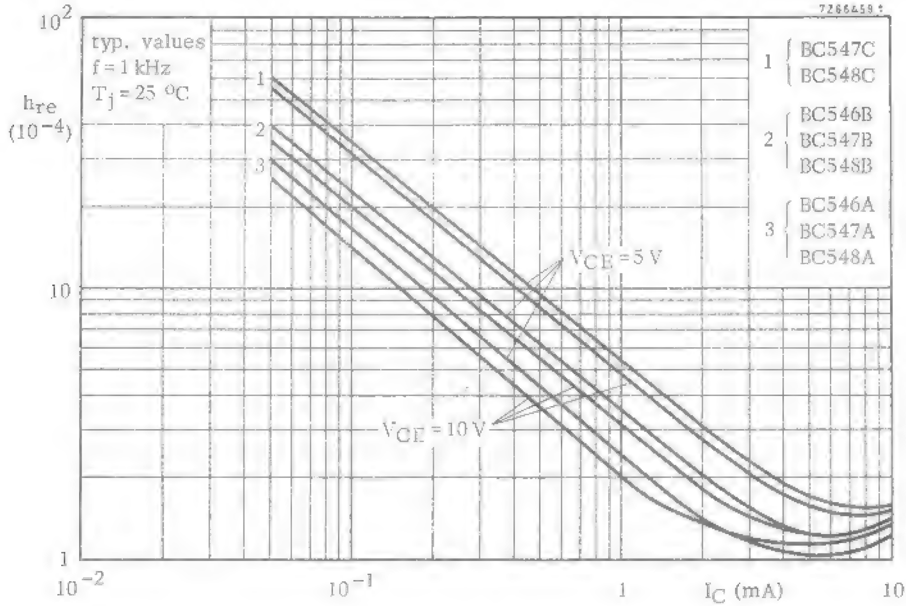

7Z68047
400
f_T
(MHz)
$V_{CE} = 5$V
$T_j = 25$°C
f = 35MHz
typ
200
0
10^{-1}
1
10
I_C(mA)
10^2

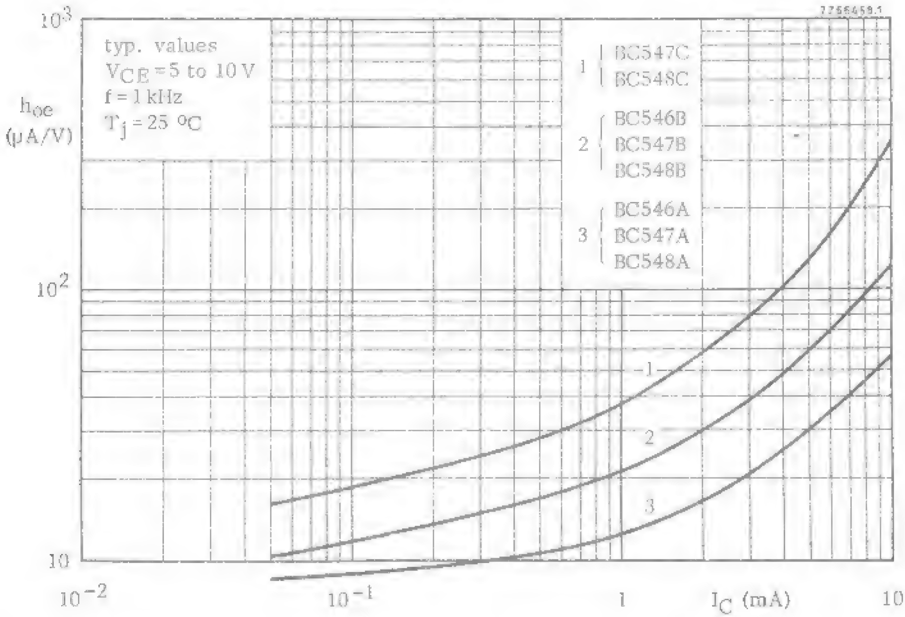

7Z61398
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
C_c
(pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30


7Z61399
$I_C = I_c = 0$
f = 1MHz
$T_j = 25°C$
C_e
(pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5


7Z66460.1
typ. values
T_j = 25 °C
f = 1 kHz
h_{ie} (kΩ)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
V_{CE} = 10 V
V_{CE} = 5 V
I_C (mA)


7Z66461.1
typ. values
T_j = 25 °C
f = 1 kHz
h_{fe}
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
V_{CE} = 10 V
5 V
10 V
5 V
10 V
5 V
I_C (mA)


7266459.2
typ. values
f = 1 kHz
T_j = 25 °C
h_{re}
(10^{-4})
10^2
10
1
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
V_{CE} = 5 V
V_{CE} = 10 V
10^{-2}
10^{-1}
1
I_C (mA)
10


7266459.1
typ. values
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
10^3
10^2
10
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
1
2
3
10^{-2}
10^{-1}
1
I_C (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variants, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

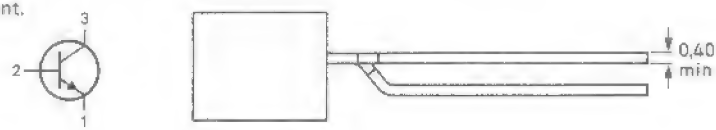
QUICK REFERENCE DATA

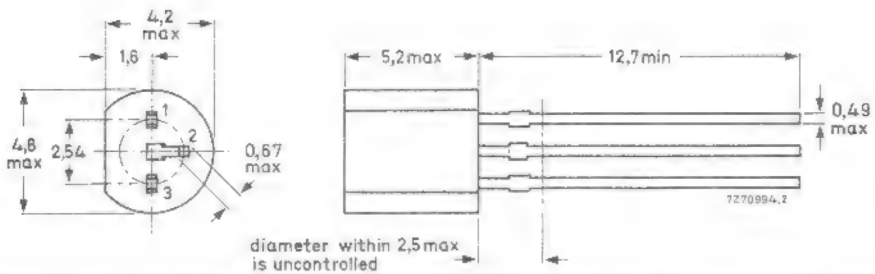
			BC549	BC550	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max	30	50	V
Collector-emitter voltage (open base)	V_{CEO}	max	30	45	V
Collector current (peak value)	I_{CM}	max	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	500	500	mW
Junction temperature	T_j	max	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	240 900	240 900	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 30 Hz to 15 kHz	F	typ <	1,4 4	1,4 3	dB dB
f = 1 kHz; B = 200 Hz	F	typ	1,2	1	dB
f = 10 Hz to 50 Hz (equivalent noise voltage)	V_n	<	–	0,135	μV

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

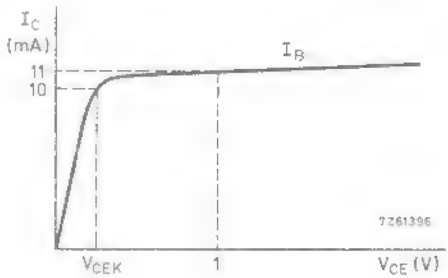
			BC549	BC550	
Voltage					
Collector-base voltage (open emitter)	V_{CBO}	max.	30	50	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	30	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V
Current					
Collector current (d. c.)	I_C	max.		100	mA
Collector current (peak value)	I_{CM}	max.		200	mA
Emitter current (peak value)	$-I_{EM}$	max.		200	mA
Base current (peak value)	I_{BM}	max.		200	mA
Power dissipation					
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.		500	mW
Temperature					
Storage temperature	T_{stg}			−65 to +150	^oC
Junction temperature	T_j	max.		150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0, 25	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0, 15	$^oC/mW$

CHARACTERISTICS — $T_j = 25\,^{o}C$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	15	nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 150\,^{o}C$	I_{CBO}	<	5	μA
Base emitter voltage				
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	660	mV
			580 to 700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV
Saturation voltages 2)				
$I_C = 10$ mA; $I_B = 0,5$ mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
$I_C = 100$ mA; $I_B = 5$ mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV
Knee voltage				
$I_C = 10$ mA; I_B = value for which $I_C = 11$ mA at $V_{CE} = 1$ V	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz

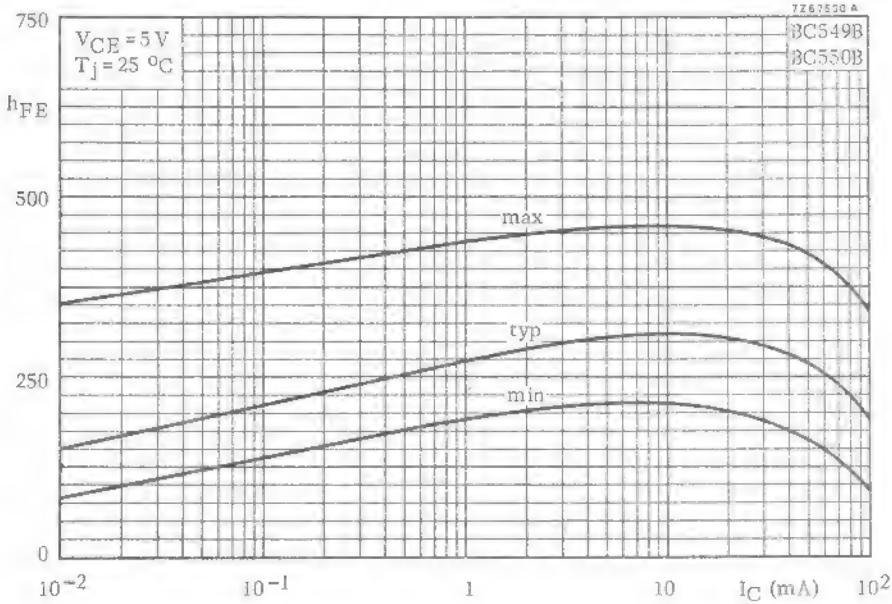
1) V_{BE} decreases by about 2 mV/^{o}C with increasing temperature.

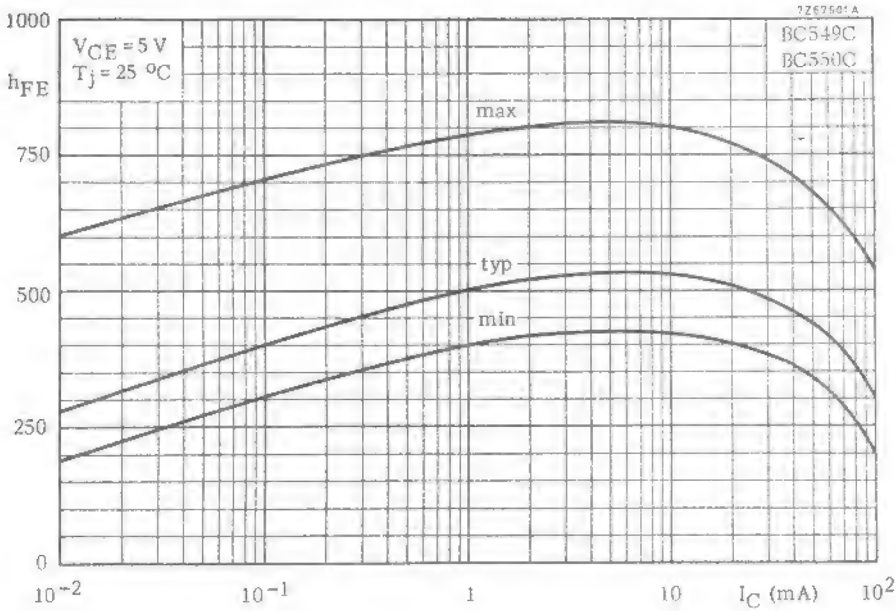
2) V_{BEsat} decreases by about 1,7 mV/^{o}C with increasing temperature.

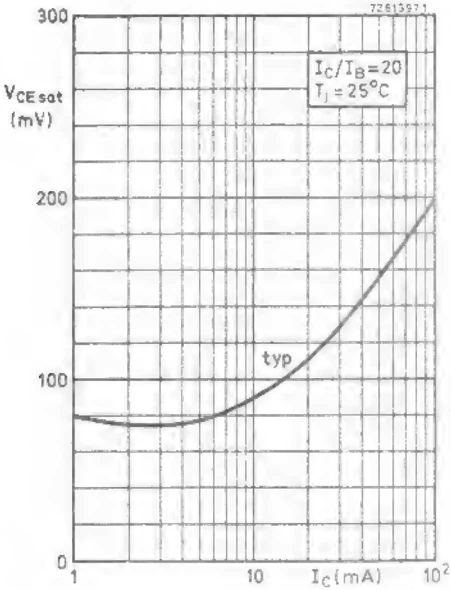
CHARACTERISTICS (continued) — $T_j = 25\ ^oC$ unless otherwise specified

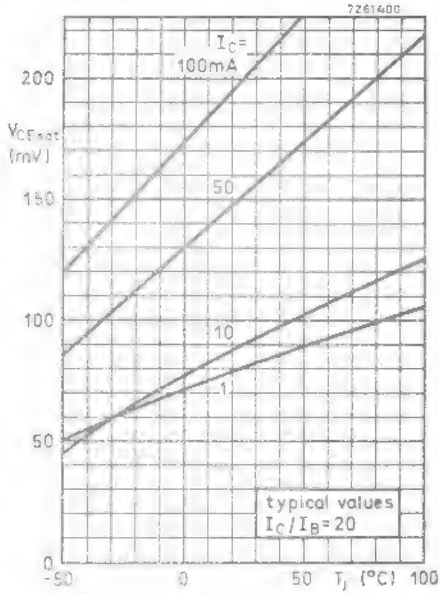
			BC549	BC550	
Small signal current gain at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	240	240	
		<	900	900	
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.	1,4	1,4	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	typ.	1,2	1	dB
		<	4	4	dB
Equivalent noise voltage at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	max.	–	0,135	μV

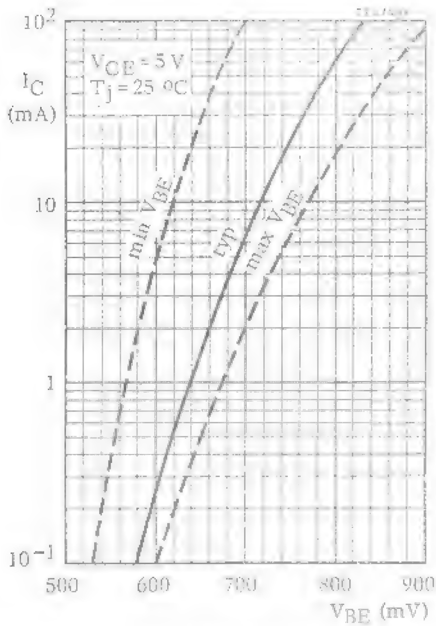
			BC549B BC550B	BC549C BC550C
D.C. current gain				
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	150	270
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	200	420
		typ.	290	520
		<	450	800

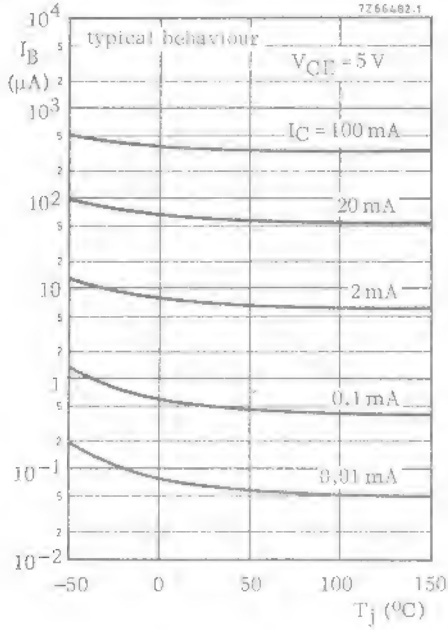

7Z67500 A
BC549B
BC550B
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

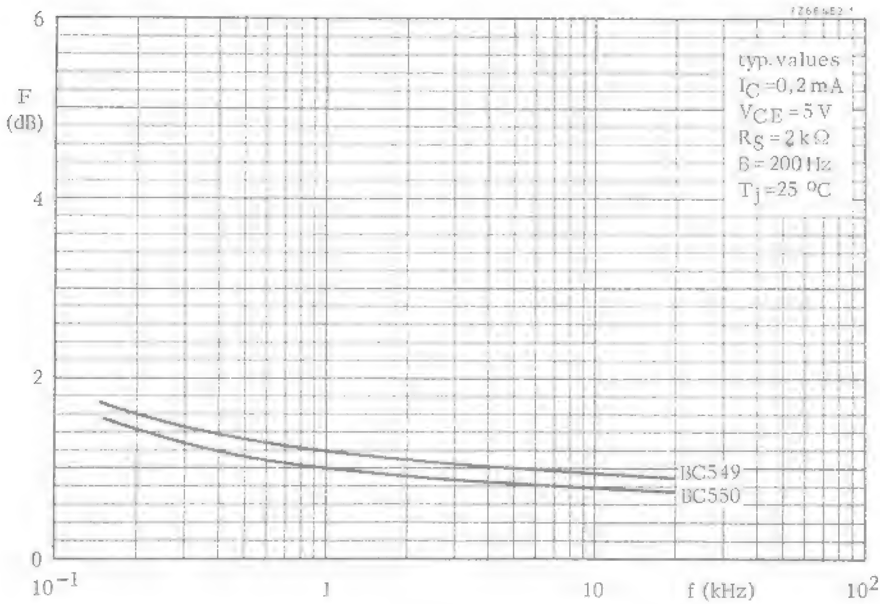

7Z67501 A
BC549C
BC550C
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
1000
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

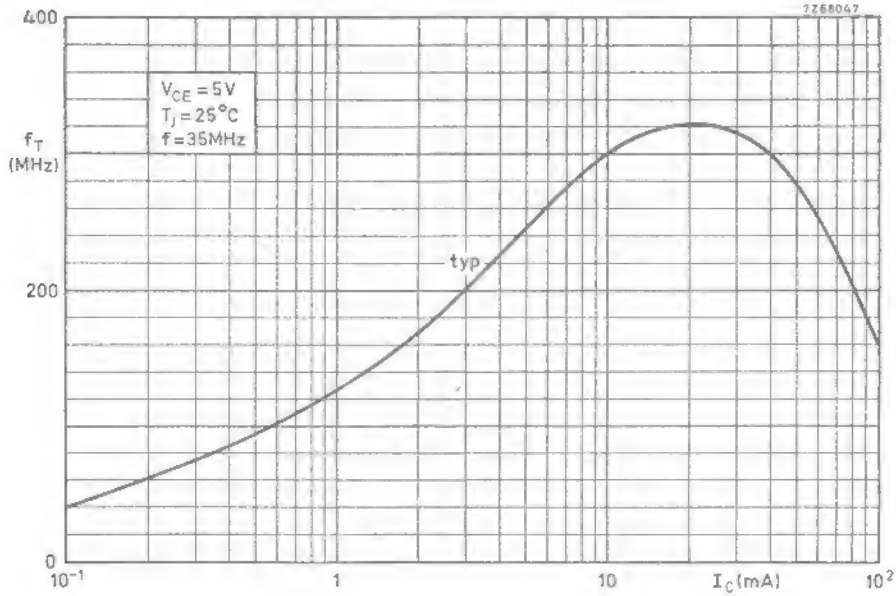

7Z61397.1
$I_C/I_B = 20$
$T_j = 25\,^{\circ}C$
V_{CEsat} (mV)
300
200
100
0
typ
1
10
I_C (mA)
10^2

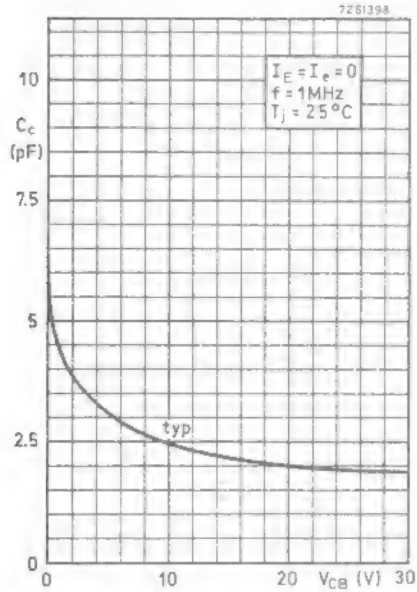

7Z61400
$I_C =$ 100 mA
50
10
1
V_{CEsat} (mV)
200
150
100
50
0
typical values
$I_C/I_B = 20$
-50
0
50
T_j (°C)
100

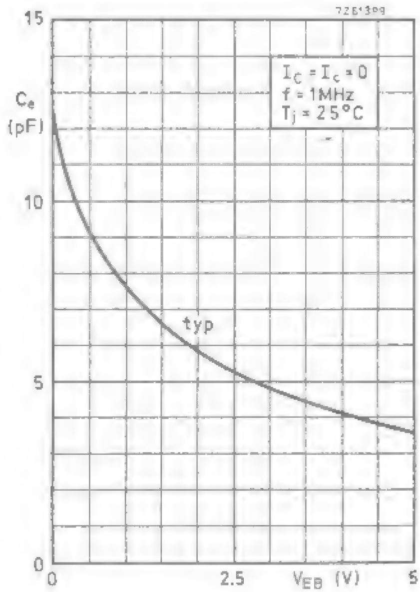

$V_{CE} = 5$ V
$T_j = 25\,^{\circ}C$
I_C (mA)
10^2
10
1
10^{-1}
min V_{BE}
typ
max V_{BE}
500
600
700
800
900
V_{BE} (mV)

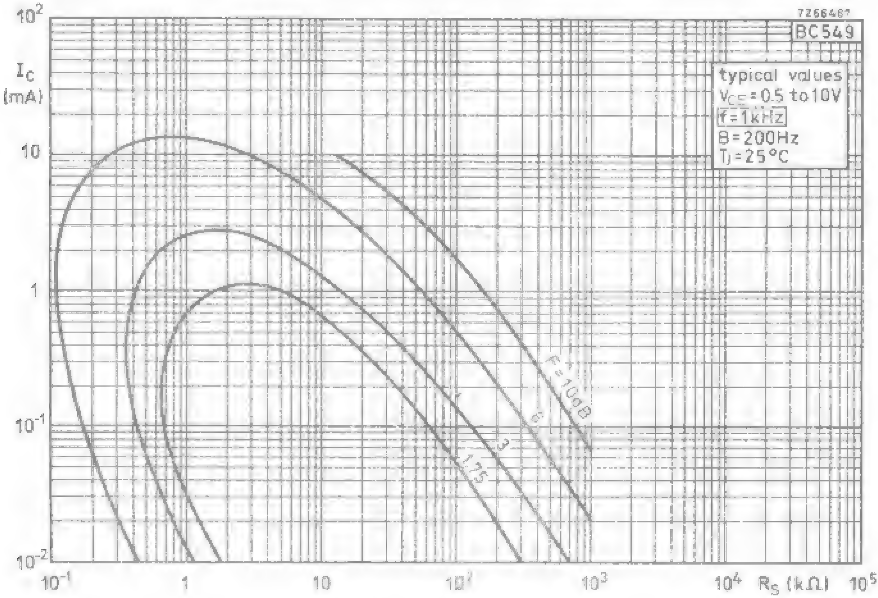

7Z66482.1
typical behaviour
V_{CE} = 5 V
I_C = 100 mA
20 mA
2 mA
0,1 mA
0,01 mA
I_B
(μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
−50
0
50
100
150
T_j (°C)


typ. values
I_C = 0,2 mA
V_{CE} = 5 V
R_S = 2 kΩ
B = 200 Hz
T_j = 25 °C
BC549
BC550
F
(dB)
6
4
2
0
10^{-1}
1
10
f (kHz)
10^2

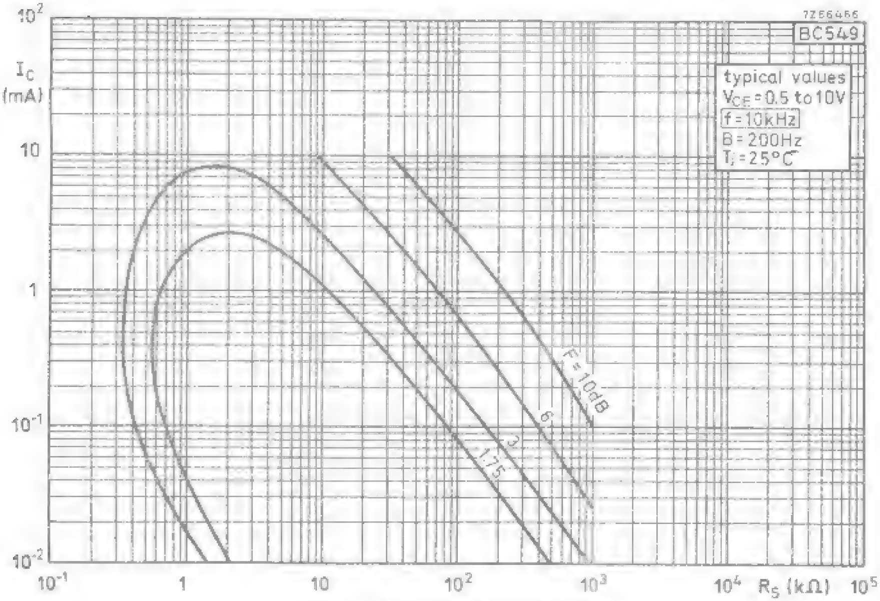

7Z68047
$V_{CE} = 5V$
$T_j = 25°C$
$f = 35MHz$
f_T
(MHz)
400
200
0
typ
10^{-1}
1
10
I_C (mA)
10^2


7Z61398
$I_E = I_e = 0$
$f = 1MHz$
$T_j = 25°C$
C_c
(pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30

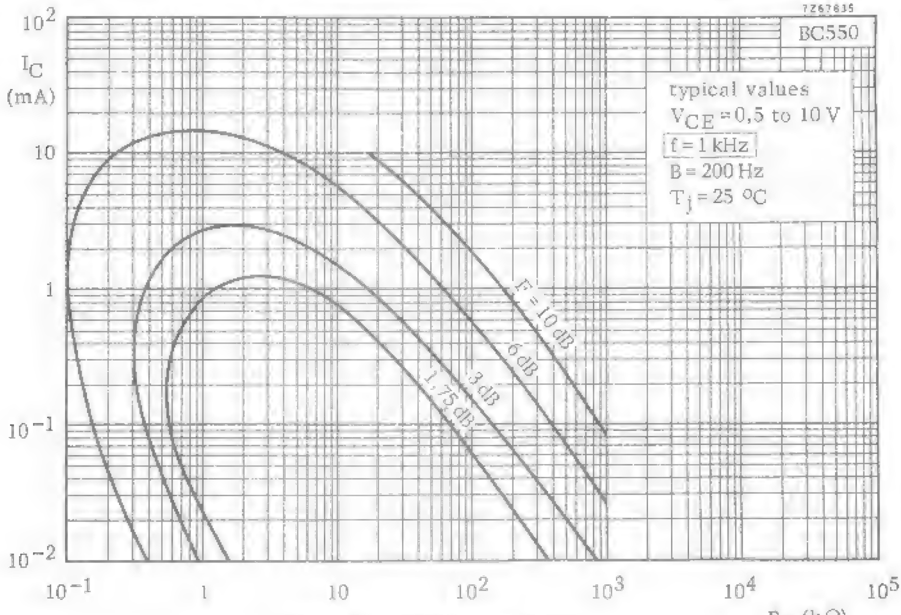

7Z61399
$I_C = I_c = 0$
$f = 1MHz$
$T_j = 25°C$
C_e
(pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5



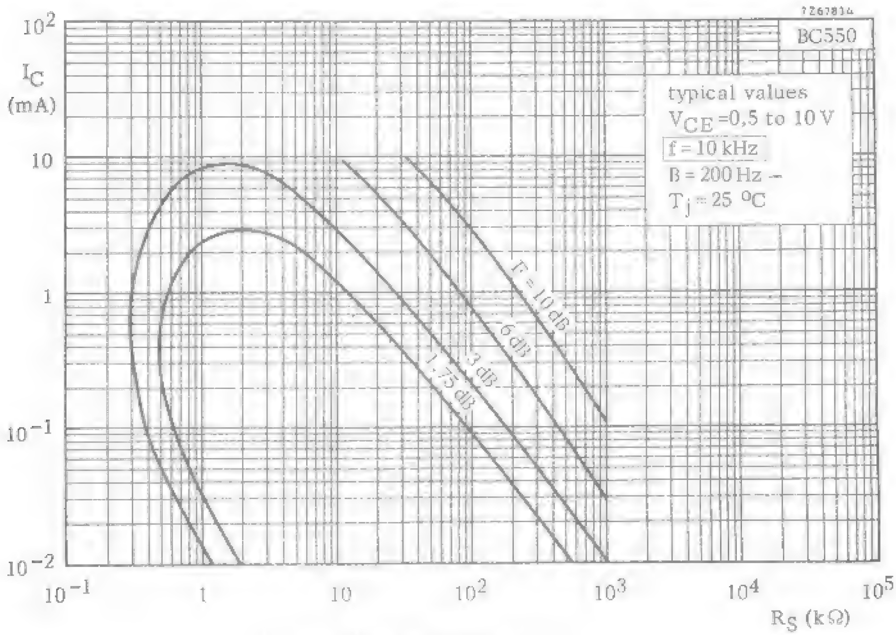
Curves of constant noise figure



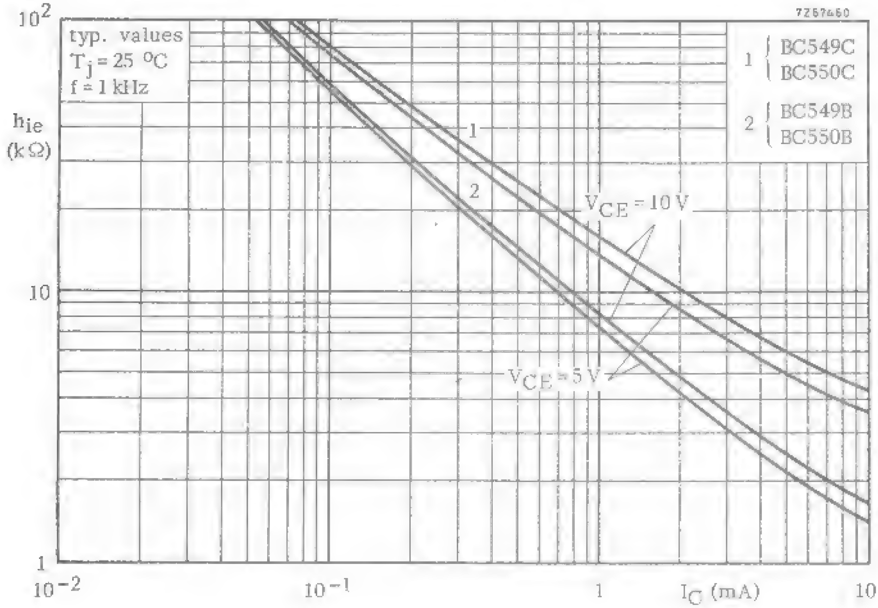
Curves of constant noise figure

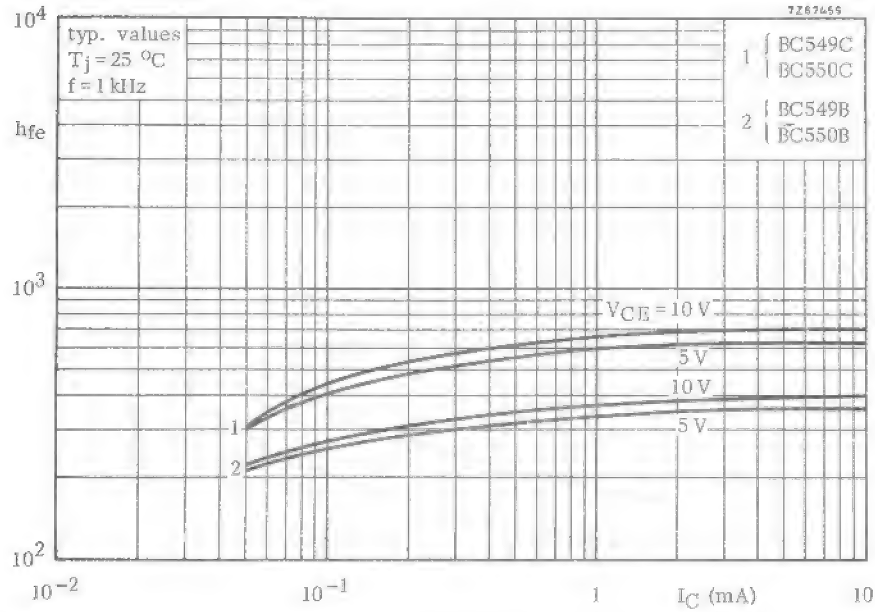


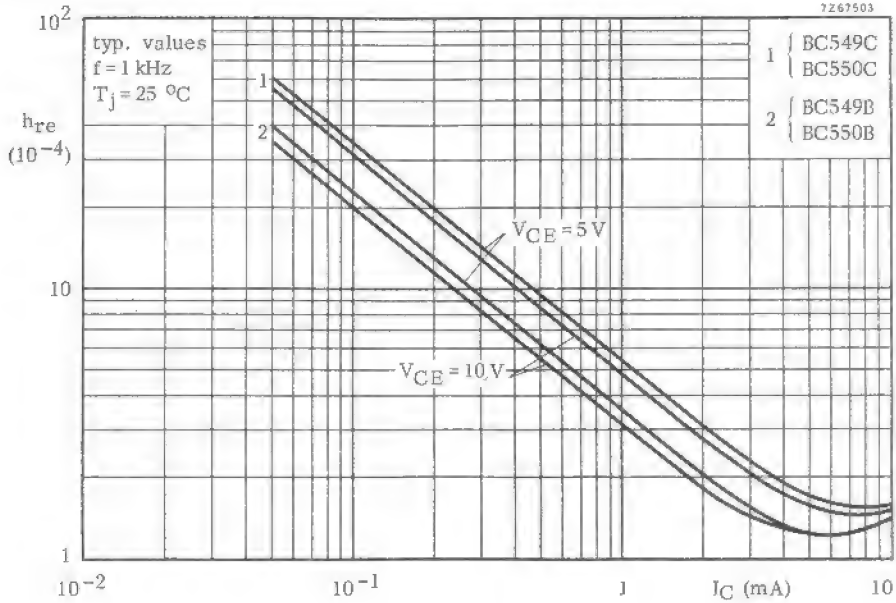
Curves of constant noise figure

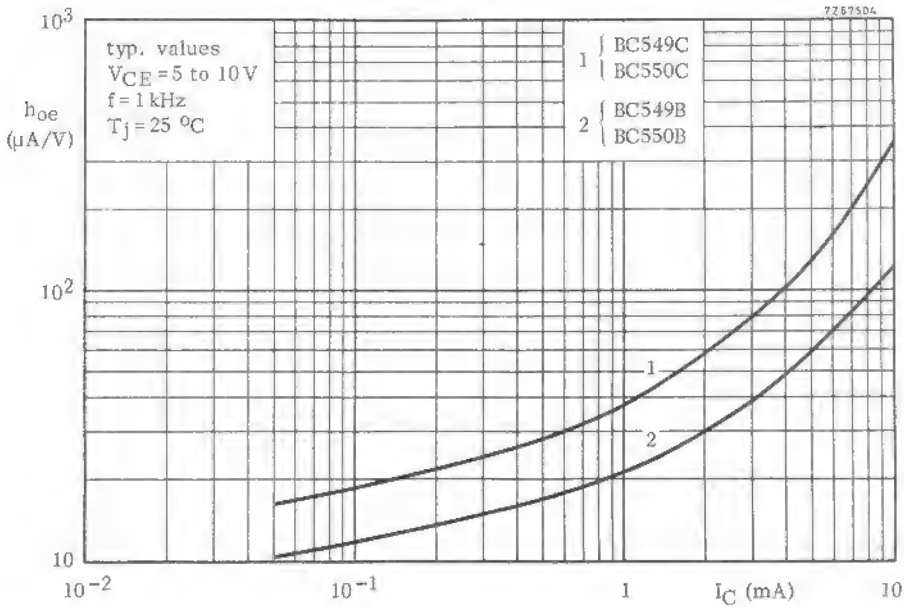


Curves of constant noise figure


7Z67460
typ. values
Tj = 25 °C
f = 1 kHz
hie
(kΩ)
1 BC549C BC550C
2 BC549B BC550B
1
2
VCE = 10 V
VCE = 5 V
10^2
10
1
10^-2
10^-1
1
IC (mA)
10


7Z67459
typ. values
Tj = 25 °C
f = 1 kHz
hfe
1 BC549C BC550C
2 BC549B BC550B
VCE = 10 V
5 V
10 V
5 V
1
2
10^4
10^3
10^2
10^-2
10^-1
1
IC (mA)
10


7Z67503
typ. values
f = 1 kHz
T_j = 25 °C
h_{re}
(10^{-4})
1 { BC549C BC550C
2 { BC549B BC550B
V_{CE} = 5 V
V_{CE} = 10 V
10^2
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z67504
typ. values
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
1 { BC549C BC550C
2 { BC549B BC550B
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose p-n-p transistors in plastic TO-92 envelopes, especially suitable for use in driver stages of audio amplifiers.

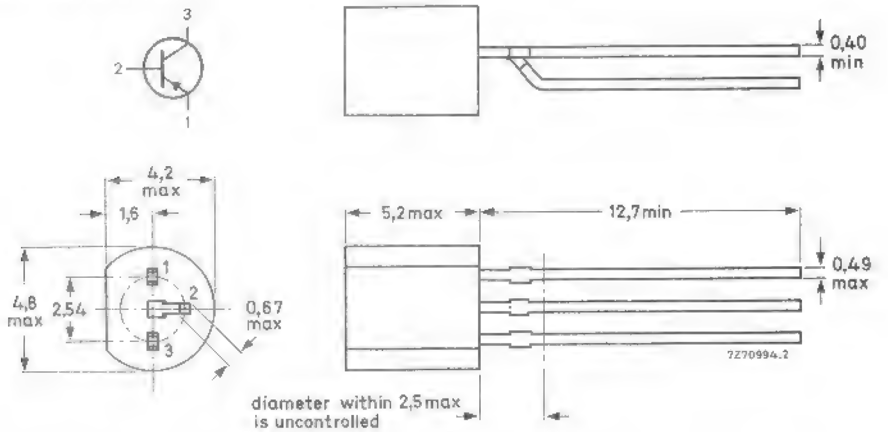
QUICK REFERENCE DATA

			BC556	BC557	BC558	
Collector-emitter voltage ($+V_{BE} = 1$ V)	$-V_{CEX}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	V
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Total power dissipation up to $T_{amb} = 25$ °C	P_{tot}	max.		500		mW
Junction temperature	T_j	max.		150		°C
Small-signal current gain $-I_C = 2$ mA; $-V_{CE} = 5$ V; f = 1 kHz	h_{fe}			75 to 900		
Transition frequency at f = 35 MHz $-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.		200		MHz
Noise figure at $R_S = 2$ kΩ $-I_C = 200$ μA; $-V_{CE} = 5$ V f = 1 kHz; B = 200 Hz	F	<		10		dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC556	BC557	BC558	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	50	30	V
Collector-emitter voltage ($+V_{BE} = 1$ V)	$-V_{CEX}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW
Storage temperature	T_{stg}		−65 to + 150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified.

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 25\ ^oC$	$-I_{CBO}$	typ.	1	nA
		<	15	nA
$T_j = 150\ ^oC$	$-I_{CBO}$	<	4	μA
Base-emitter voltage*				
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	650	mV
			600 to 750	mV
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	<	820	mV
Saturation voltages**				
$-I_C = 10$ mA; $-I_B = 0{,}5$ mA	$-V_{CEsat}$	typ.	60	mV
		<	300	mV
	$-V_{BEsat}$	typ.	750	mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ.	180	mV
		<	650	mV
	$-V_{BEsat}$	typ.	930	mV

* $-V_{BE}$ decreases by about 2 mV/K with increasing temperature.

** $-V_{BEsat}$ decreases by about 1,7 mV/K with increasing temperature.

Knee voltage				
$-I_C$ = 10 mA; $-I_B$ = value for which		typ.	250	mV
$-I_C$ = 11 mA at $-V_{CE}$ = 1 V	$-V_{CEK}$	<	600	mV

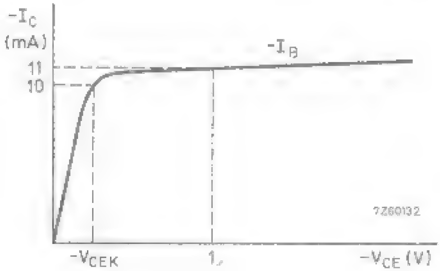


Fig. 2.

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CE}$ = 10 V	C_c	typ.	4	pF
Transition frequency at f = 35 MHz				
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	200	MHz
Small-signal current gain at f = 1 kHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}		75 to 900	
Noise figure at R_S = 2 kΩ				
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V		typ.	2	dB
f = 1 kHz; B = 200 Hz	F	<	10	dB

			BC556 BC557 BC558	BC556A BC557A BC558A	BC556B BC557B BC558B	 BC557C BC558C
D.C. current gain						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	75	125	220	420
		<	900	250	475	800

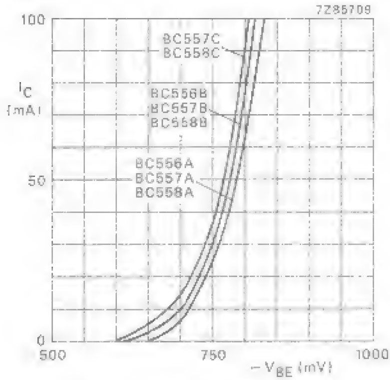


Fig. 3 $-V_{CE} = 5$ V; $T_j = 25$ °C.

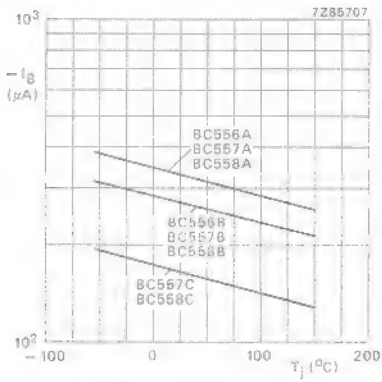


Fig. 4 $-V_{CE} = 5$ V; $I_C = 50$ mA.

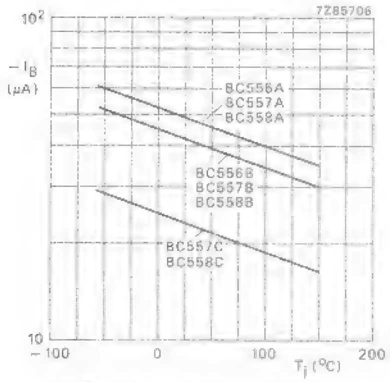


Fig. 5 $-V_{CE} = 5$ V; $I_C = 10$ mA.

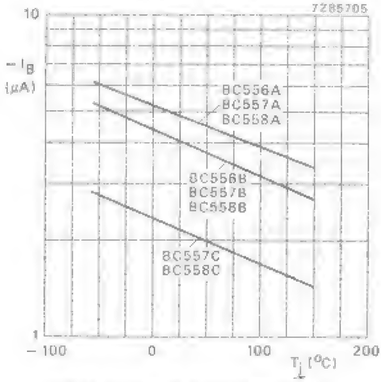


Fig. 6 $-V_{CE} = 5$ V; $I_C = 1$ mA.

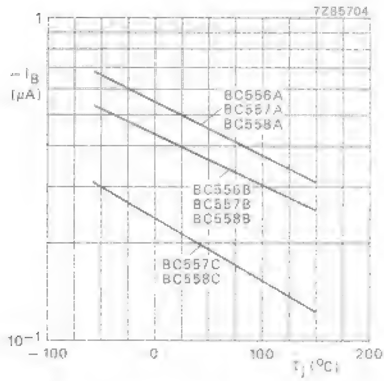


Fig. 7 $-V_{CE} = 5$ V; $I_C = 0{,}1$ mA.

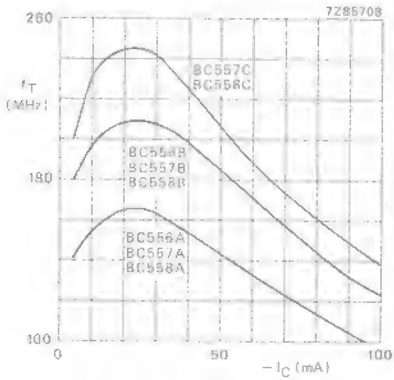


Fig. 8 $-V_{CE} = 5$ V; $T_j = 25$ °C;
f = 35 MHz.

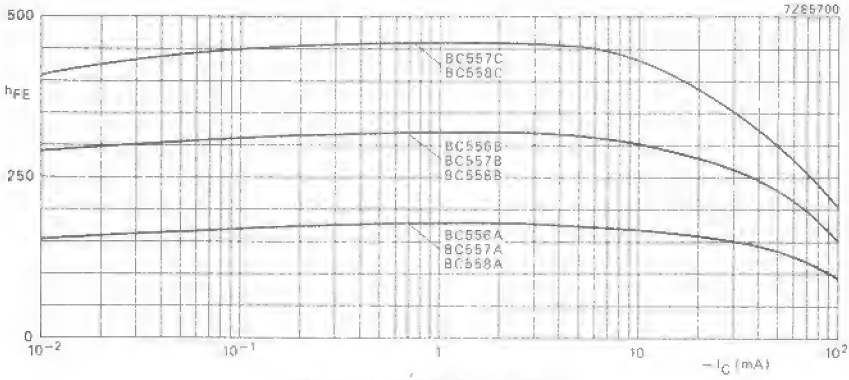


Fig. 9 $-V_{CE} = 5$ V; $T_j = 25$ °C.

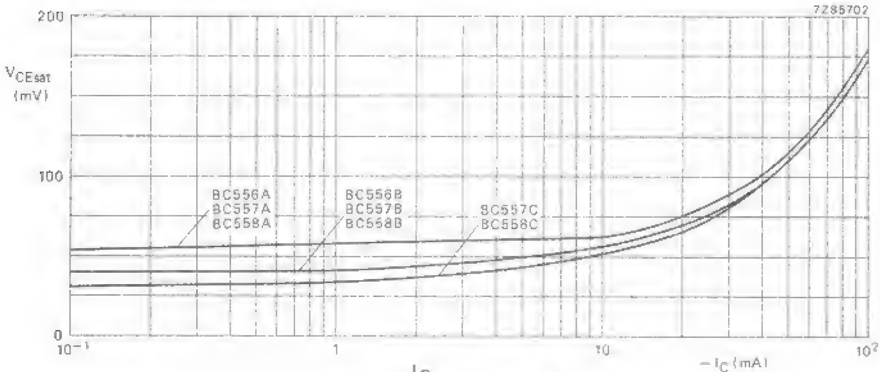


Fig. 10 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

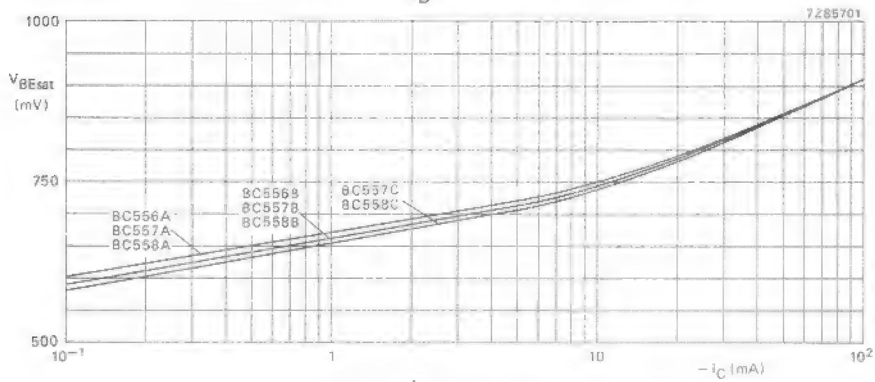


Fig. 11 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

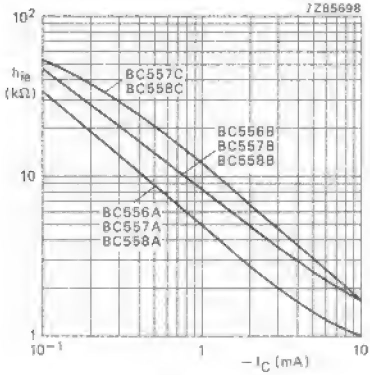


Fig. 12.

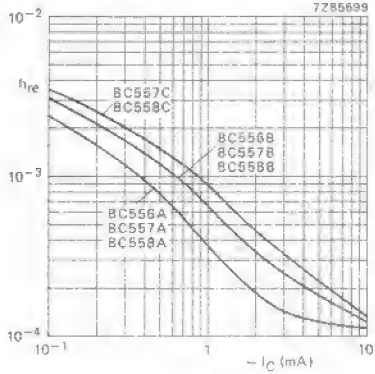


Fig. 13.

For Figs 12, 13, 14 and 15 the following conditions apply: $-V_{CE}$ = 5 V; f = 1 kHz; T_j = 25 °C.

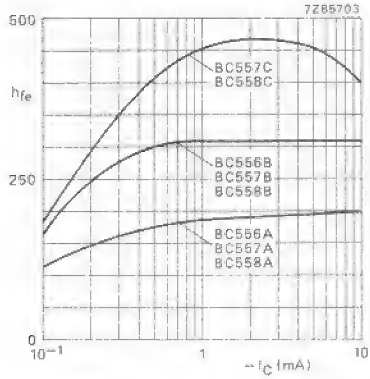


Fig. 14.

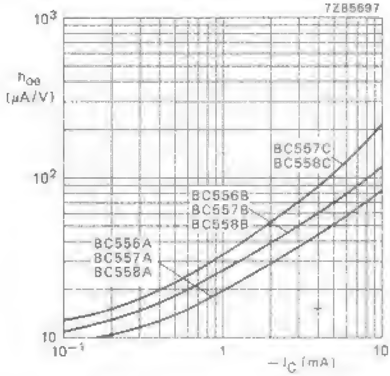


Fig. 15.

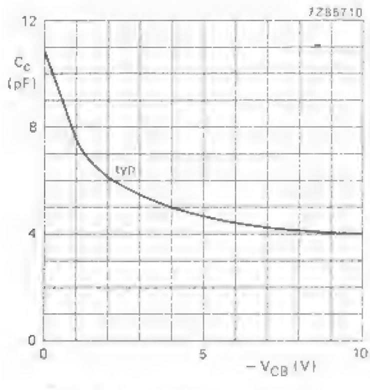


Fig. 16 f = 1 MHz; T_j = 25 °C.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

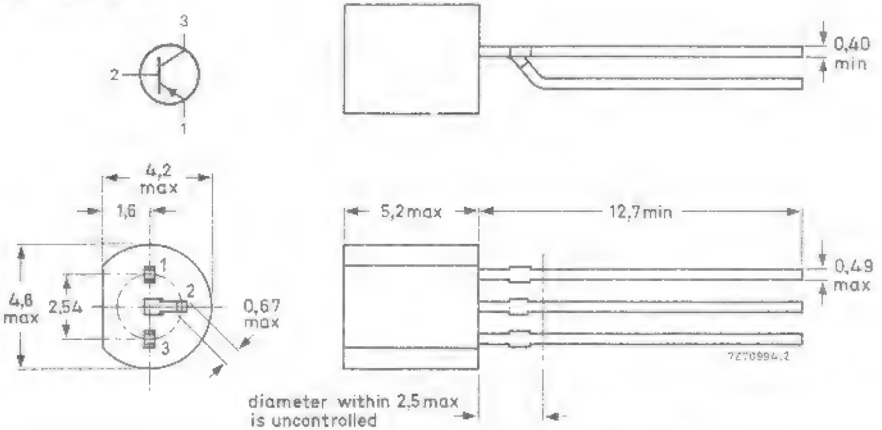
QUICK REFERENCE DATA

			BC559	BC560	
Collector-emitter voltage ($+V_{BE} = 1$ V)	$-V_{CEX}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150	150	^oC
Small-signal current gain $-I_C = 2$ mA; $-V_{CE} = 5$ V; f = 1 kHz	h_{fe}	>	125	125	
		<	900	900	
Transition frequency $-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	200	200	MHz
Noise figure at $R_s = 2\ k\Omega$ $-I_C = 200\ \mu A$; $-V_{CE} = 5$ V f = 30 Hz to 15 kHz	F	typ.	1,2	1	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	<	4	4	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC559	BC560	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	50	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Emitter-base voltage (open collector)	$-V_{CBO}$	max.	5	5	V

Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB}$ = 30 V; T_j = 25 °C	$-I_{CBO}$	typ.	1	nA
		<	15	nA
T_j = 150 °C	$-I_{CBO}$	<	4	μA
Base-emitter voltage*				
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	650	mV
			600 to 750	mV
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	<	820	mV
Saturation voltages**				
$-I_C$ = 10 mA; $-I_B$ = 0,5 mA	$-V_{CEsat}$	typ.	60	mV
		<	300	mV
	$-V_{BEsat}$	typ.	750	mV
$-I_C$ = 100 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	typ.	180	mV
		<	650	mV
	$-V_{BEsat}$	typ.	930	mV

* $-V_{BE}$ decreases by about 2 mV/K with increasing temperature.
** $-V_{BEsat}$ decreases by about 1,7 mV/K with increasing temperature.

Knee voltage

$-I_C$ = 10 mA; $-I_B$ = value for which $-I_C$ = 11 mA at $-V_{CE}$ = 1 V	$-V_{CEK}$	typ.	250 mV
		<	600 mV

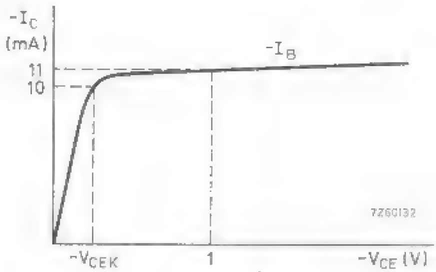


Fig. 2.

Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	4 pF
Transition frequency at f = 35 MHz			
$-I_C$ = 10 mA; $-V_{CE}$ = 5 B	f_T	typ.	200 MHz
Small-signal current gain at f = 1 kHz			
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}		125 to 900

Noise figure at R_S = 2 kΩ

			BC559	BC560	
$-I_C$ = 200 µA; $-V_{CE}$ = 5 V					
f = 30 Hz to 15 kHz	F	typ.	1,2	1	dB
		>	4	3 -	dB
f = 1 kHz; B = 200 Hz	F	typ.	1	1	dB
		<	4	4	dB
Equivalent noise voltage at R_S = 2 kΩ					
$-I_C$ = 200 µA; $-V_{CE}$ = 5 V; f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	<	–	0,11	µV

			BC559 BC560	BC559A BC560A	BC559B BC560B	BC559C BC560C
D.C. current gain						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	125	125	220	420
		<	900	250	470	800

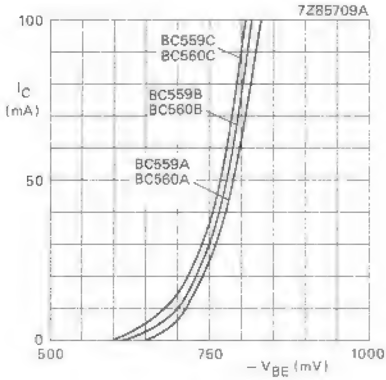


Fig. 3 $-V_{CE} = 5$ V; $T_j = 25$ °C.

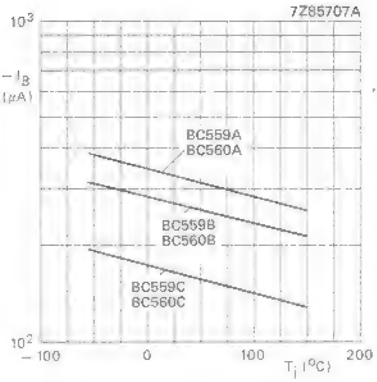


Fig. 4 $-V_{CE} = 5$ V; $I_C = 50$ mA.

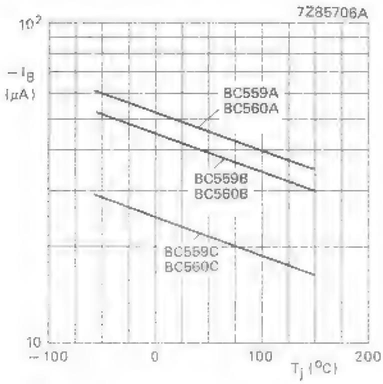


Fig. 5 $-V_{CE} = 5$ V; $I_C = 10$ mA.

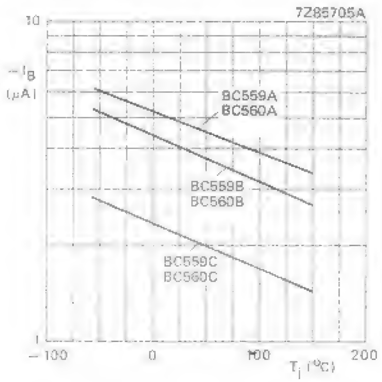


Fig. 6 $-V_{CE} = 5$ V; $I_C = 1$ mA.

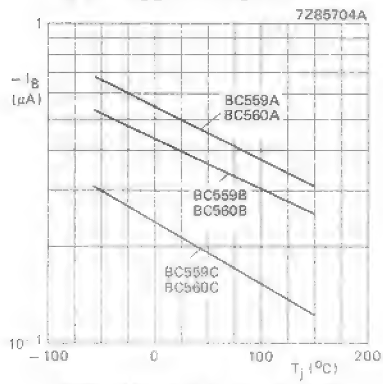


Fig. 7 $-V_{CE} = 5$ V; $I_C = 0,1$ mA.

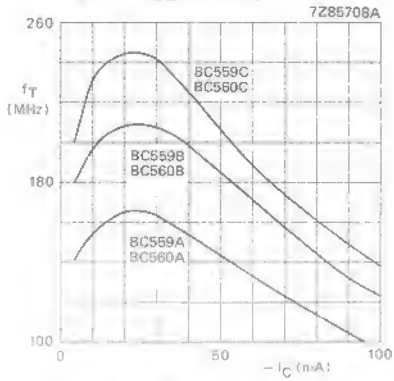


Fig. 8 $-V_{CE} = 5$ V; $T_j = 25$ °C;
f = 35 MHz.

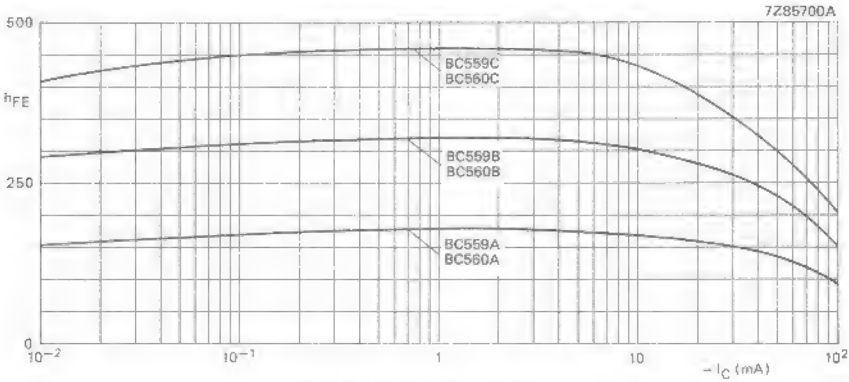


Fig. 9 $-V_{CE} = 5$ V; $T_j = 25$ °C.

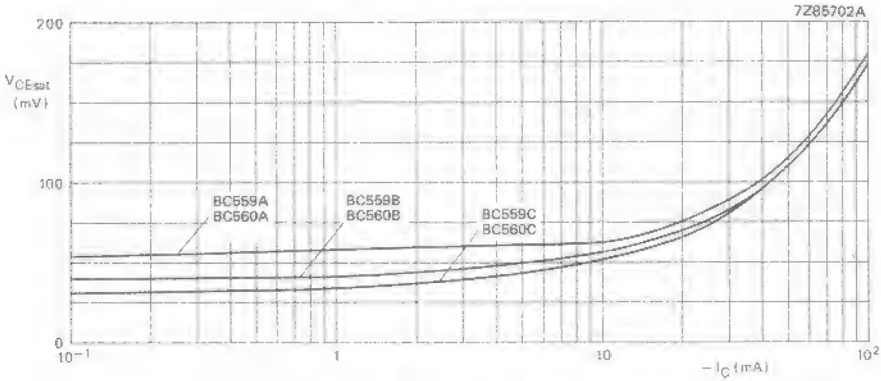


Fig. 10 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

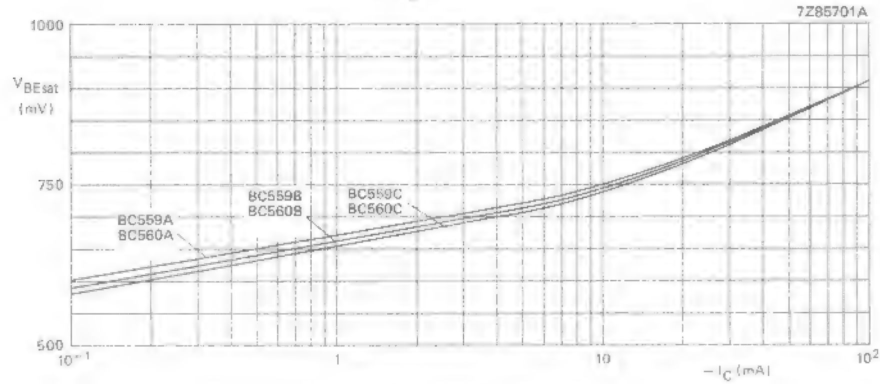


Fig. 11 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

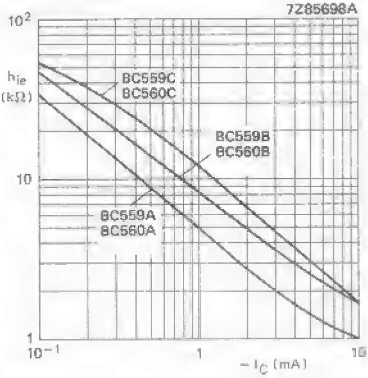


Fig. 12.

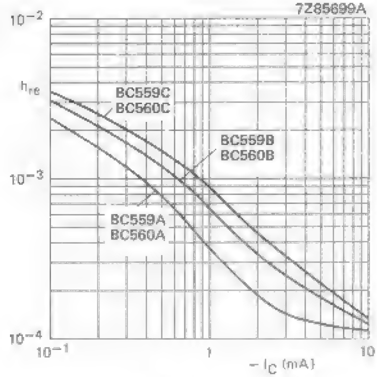


Fig. 13

For Figs 12, 13, 14 and 15 the following conditions apply: $-V_{CE}$ = 5 V; f = 1 kHz; T_j = 25 °C.

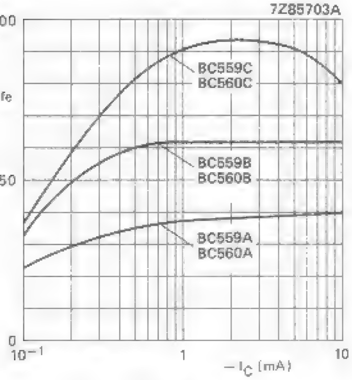


Fig. 14.

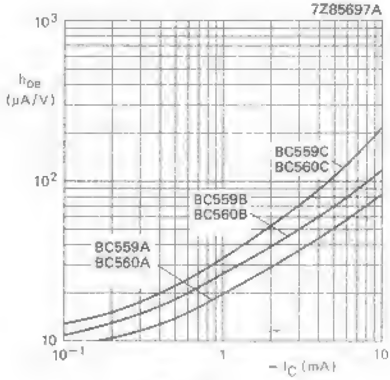


Fig. 15.

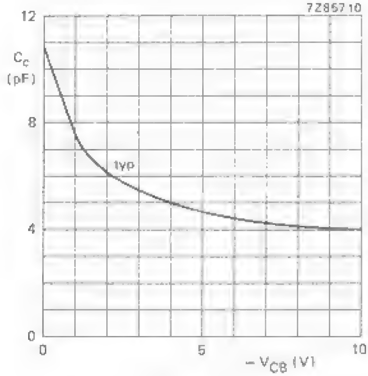


Fig. 16 f = 1 MHz; T_j = 25 °C.

curves of constant noise figure

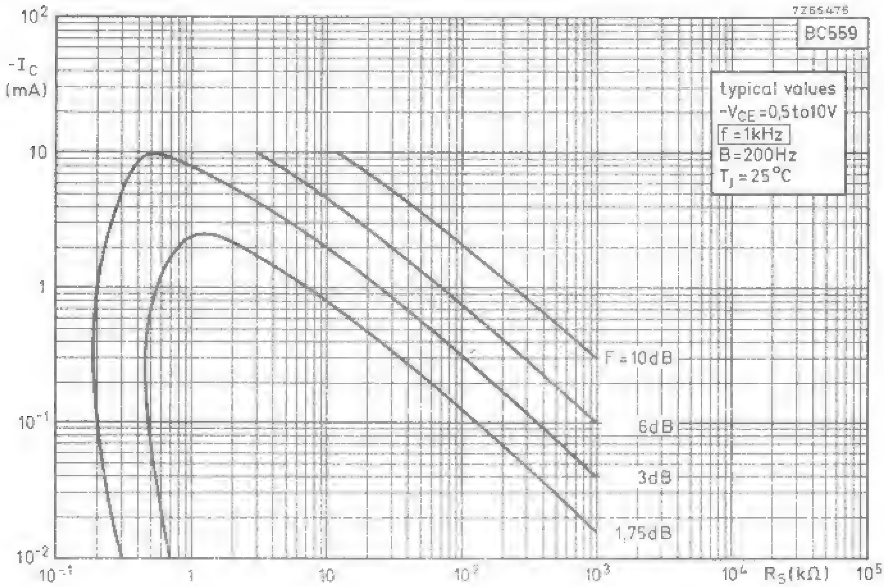


Fig. 17.

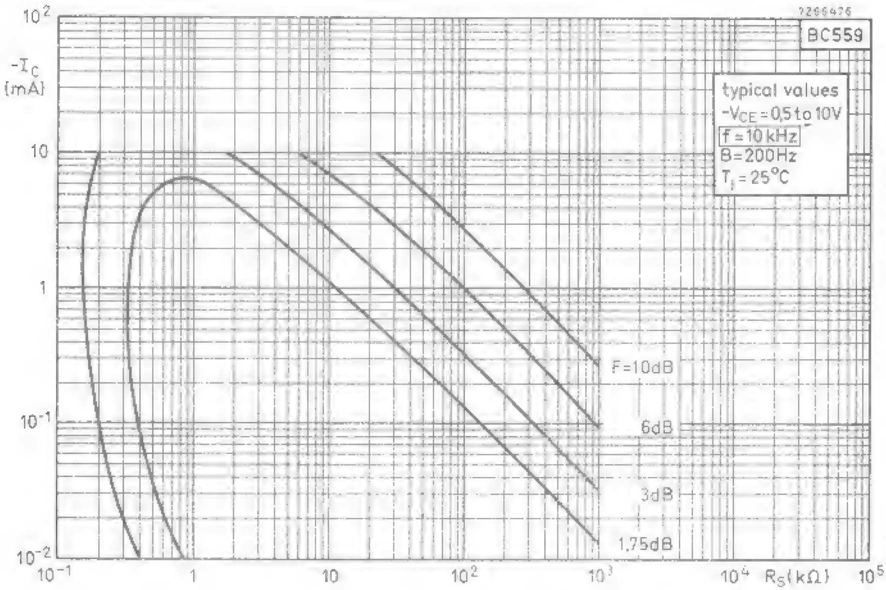


Fig. 18.

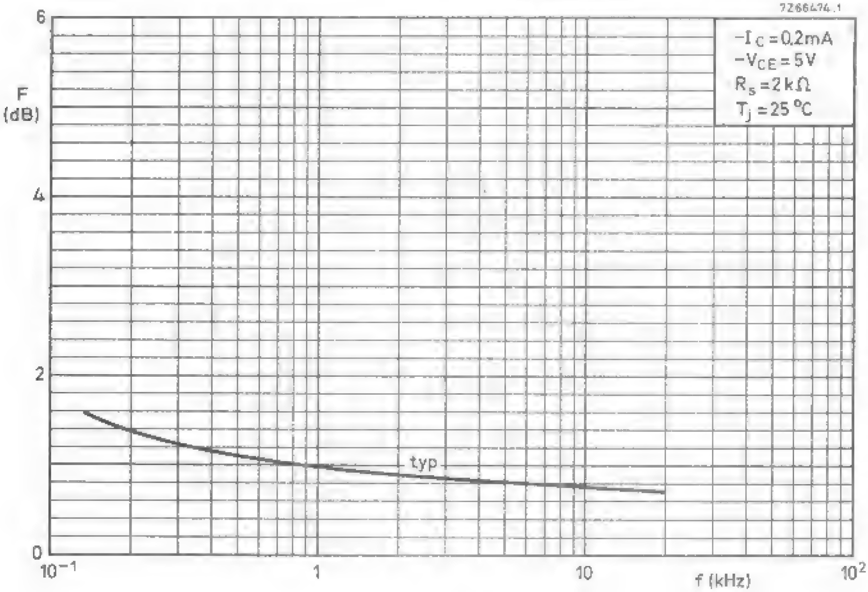

7Z66474.1
$-I_C = 0.2\,mA$
$-V_{CE} = 5\,V$
$R_s = 2\,k\Omega$
$T_j = 25\,^\circ C$
F
(dB)
6
4
2
0
typ
10^{-1}
1
10
f (kHz)
10^2

Fig. 19.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. P-N-P complements are BC636, BC638 and BC640.

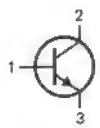
QUICK REFERENCE DATA

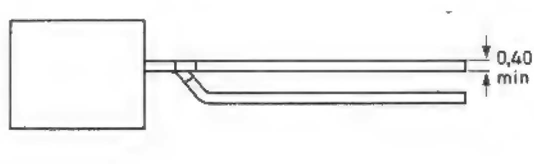
			BC635	BC637	BC639	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-current (peak value)	I_{CM}	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1	1	1	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	250	250	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	130	130	MHz

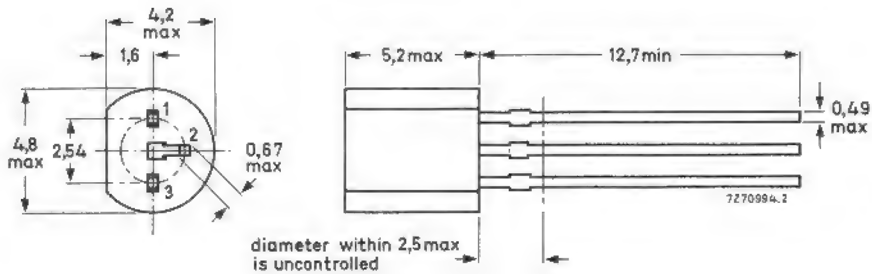
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.







RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC635	BC637	BC639	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-emitter voltage (R_{BE} = 0)	V_{CES}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		1		A
Collector current (peak value)	I_{CM}	max.		1,5		A
Emitter current (peak value)	$-I_{EM}$	max.		1,5		A
Base current (d.c.)	I_B	max.		100		mA
Base current (peak value)	I_{BM}	max.		200		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{amb} = 25 °C	P_{tot}	max.		1		W*
Storage temperature	T_{stg}			-65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	125	K/W*
From junction to case	$R_{th\ j\text{-}c}$	=	60	K/W

* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 150$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 μA
Base-emitter voltage			
$I_C = 500$ mA; $V_{CE} = 2$ V	V_{BE}	<	1 V
Saturation voltage			
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5 V
D.C. current gain			
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25
$I_C = 150$ mA; $V_{CE} = 2$ V*	h_{FE}	> 	40 250
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	130 MHz
D.C. current gain ratio of matched pairs			
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V			
BC635/BC636, BC637/BC638 and BC639/BC640	h_{FE1}/h_{FE2}	typ. <	1,3 1,6

* BC635-6 BC637-6 BC639-6	h_{FE}	> <	40 100
BC635-10 BC637-10 BC639-10	h_{FE}	> <	63 160
BC635-16 BC637-16 BC639-16	h_{FE}	> <	100 250

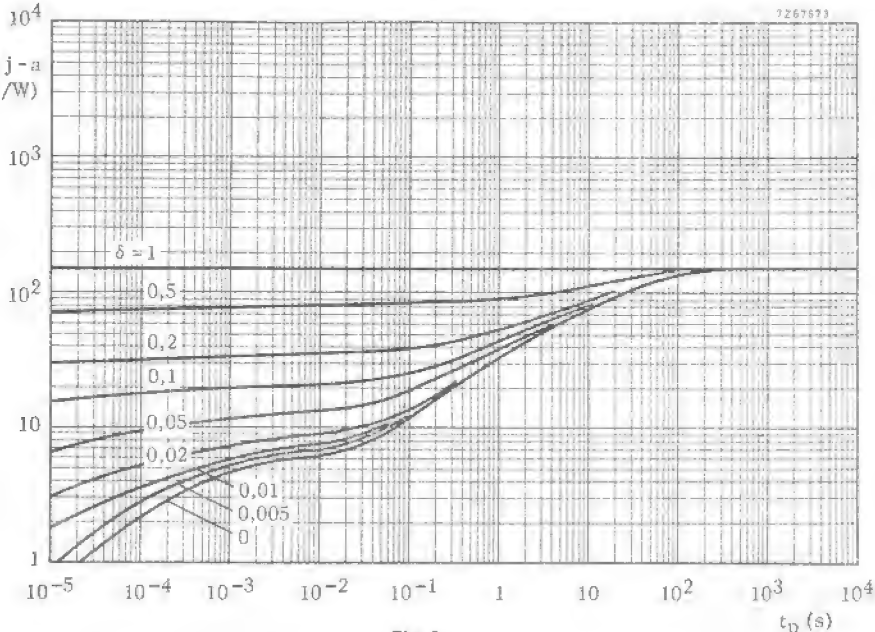

7267673
$Z_{th\ j-a}$
(°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

Fig. 2.

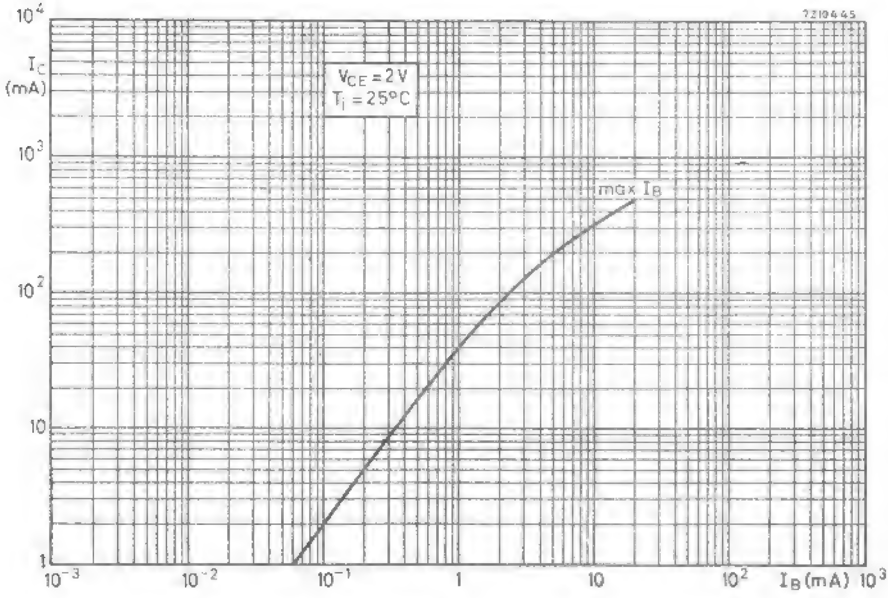

7210445
I_C
(mA)
$V_{CE} = 2\,V$
$T_j = 25°C$
max I_B
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

Fig. 3.

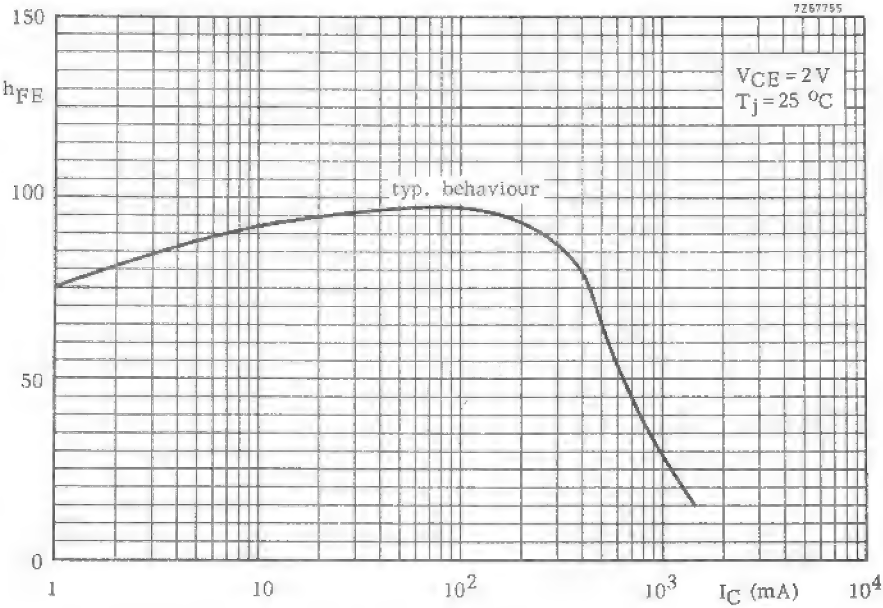

7267755
150
h_{FE}
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4
$V_{CE} = 2$ V
$T_j = 25$ °C
typ. behaviour

Fig. 4.

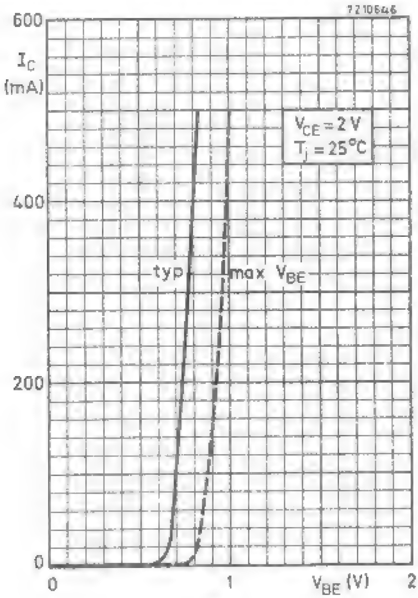

7210646
600
I_C
(mA)
400
200
0
0
1
V_{BE} (V)
2
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
max V_{BE}

Fig. 5.

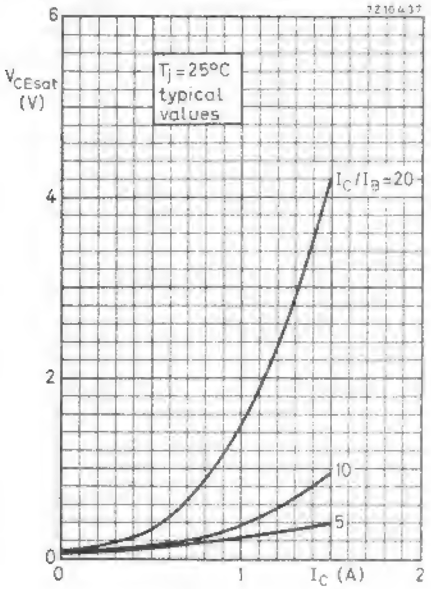


Fig. 6.

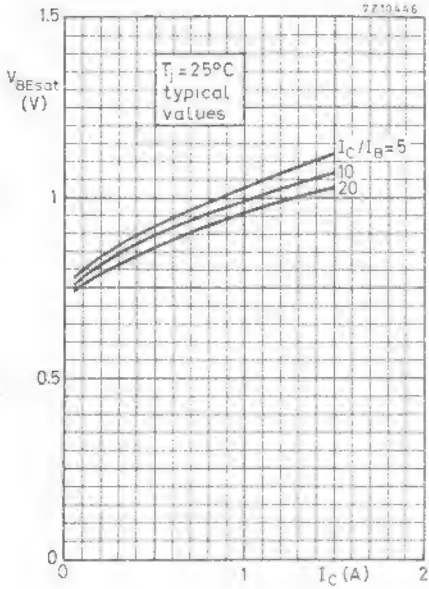


Fig. 7.

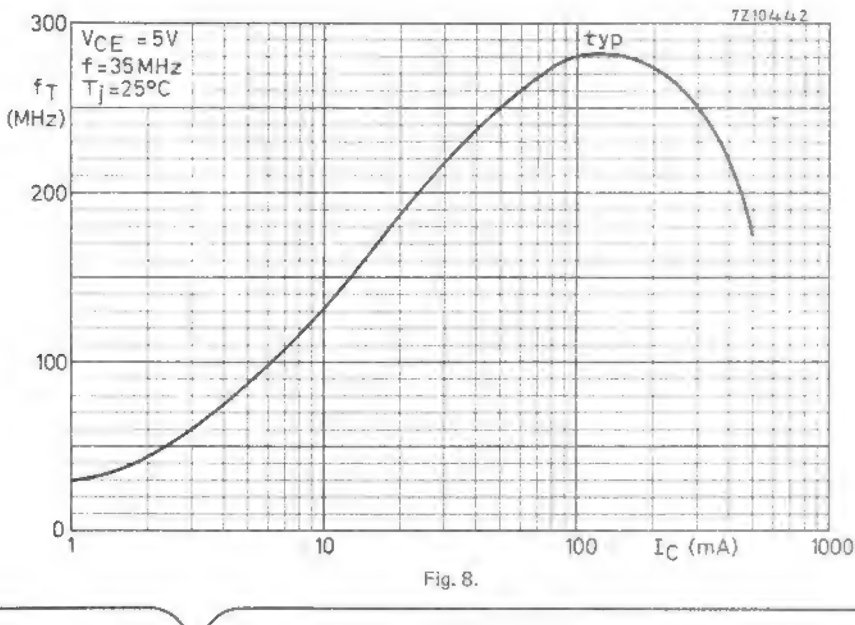


Fig. 8.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. N-P-N complements are BC635, BC637 and BC639.

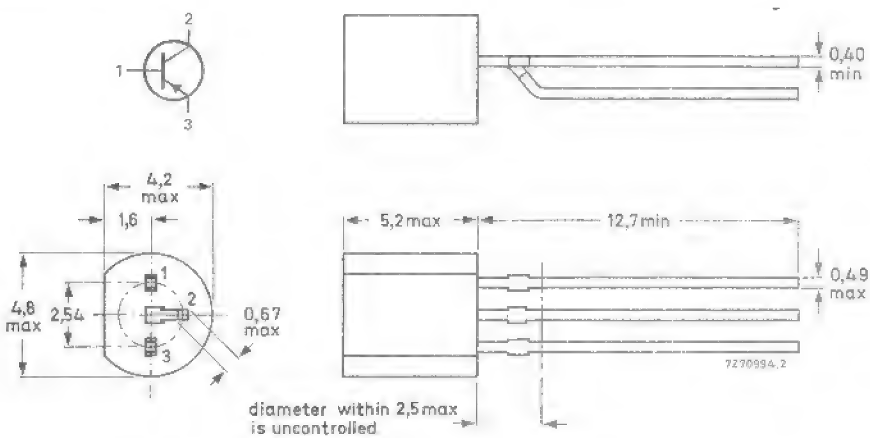
QUICK REFERENCE DATA

			BC636	BC638	BC640	
Collector-base voltage (open emitter	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1	1	1	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	250	250	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BC636	BC638	BC640	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	1,5	A
Emitter current (peak value)	I_{EM}	max.	1,5	A
Base current (d.c.)	$-I_B$	max.	100	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C	P_{tot}	max.	1	W*
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	156	K/W
From junction to ambient	$R_{th\,j\text{-}a}$	=	125	K/W*
From junction to case	$R_{th\,j\text{-}c}$	=	60	K/W

* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	100 nA
$I_E = 0; -V_{CB} = 30$ V; $T_j = 150$ °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base-emitter voltage			
$-I_C = 500$ mA; $-V_{CE} = 2$ V	$-V_{BE}$	<	1 V
Saturation voltage			
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,5 V
D.C. current gain			
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
$-I_C = 150$ mA; $-V_{CE} = 2$ V*	h_{FE}	> <	40 250 ←
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	50 MHz
D.C. current gain ratio of matched pairs			
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V			
BC635/BC636, BC637/BC638 and BC639/BC640	h_{FE1}/h_{FE2}	typ. <	1,3 1,6

* BC636-6 BC638-6 BC640-6	h_{FE}	> <	40 100 ←
BC636-10 BC638-10 BC640-10	h_{FE}	> <	63 160
BC636-16 BC638-16 BC640-16	h_{FE}	> <	100 250

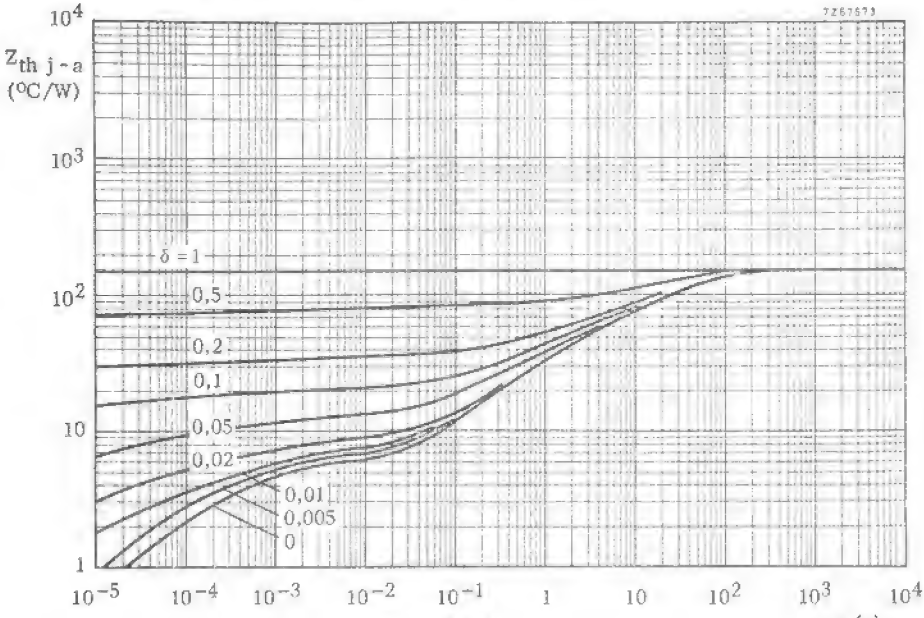

7Z67573
$Z_{th\ j-a}$ (°C/W)
$\delta = 1$
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
t_p (s)

Fig. 2.

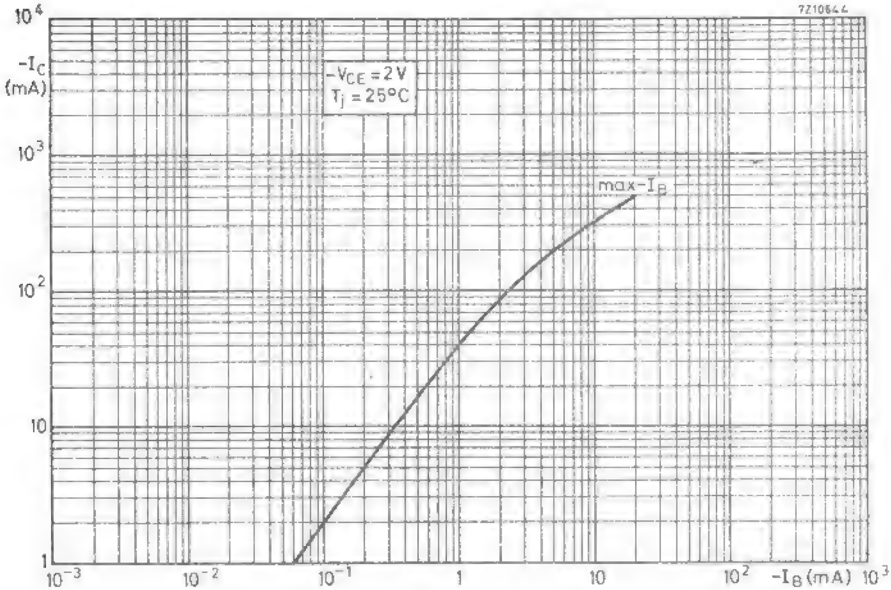

7Z10644
$-I_C$ (mA)
$-V_{CE} = 2\ V$
$T_j = 25\ °C$
max $-I_B$
$-I_B$ (mA)

Fig. 3.

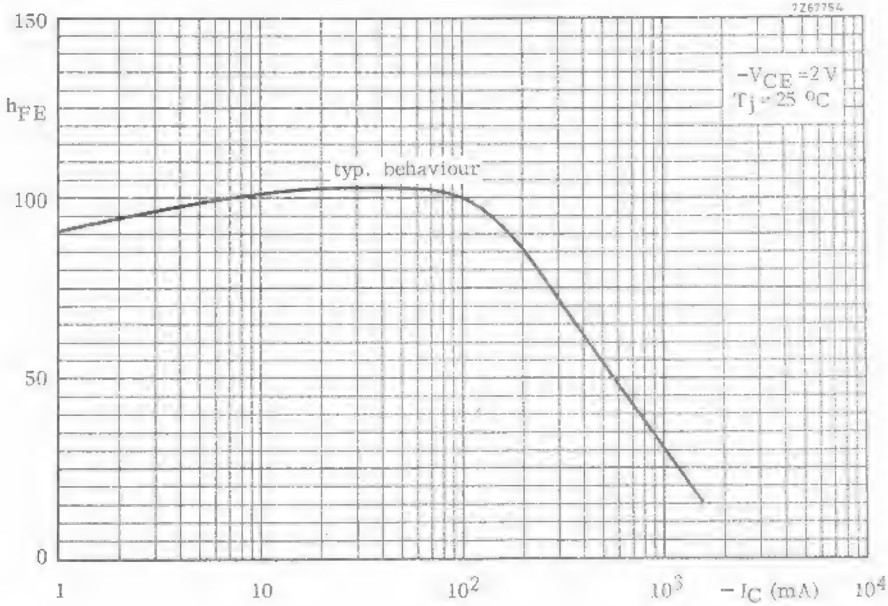

7Z67754
150
100
50
0
h_{FE}
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ. behaviour
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 4.

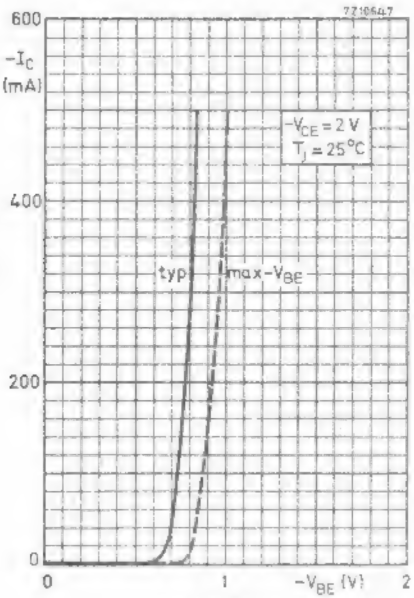

7Z10647
600
$-I_C$
(mA)
400
200
0
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
max-V_{BE}
0
1
$-V_{BE}$ (V)
2

Fig. 5.

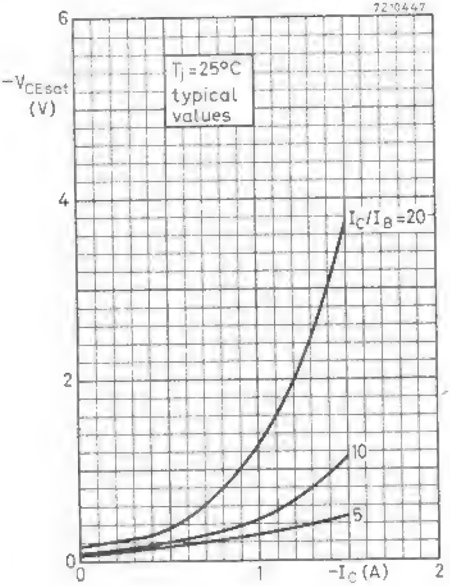


Fig. 6.

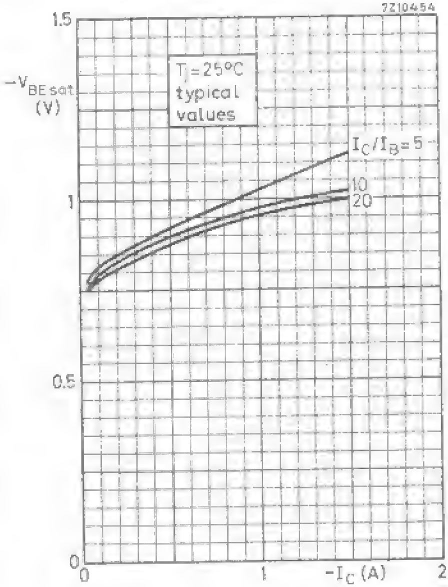


Fig. 7.

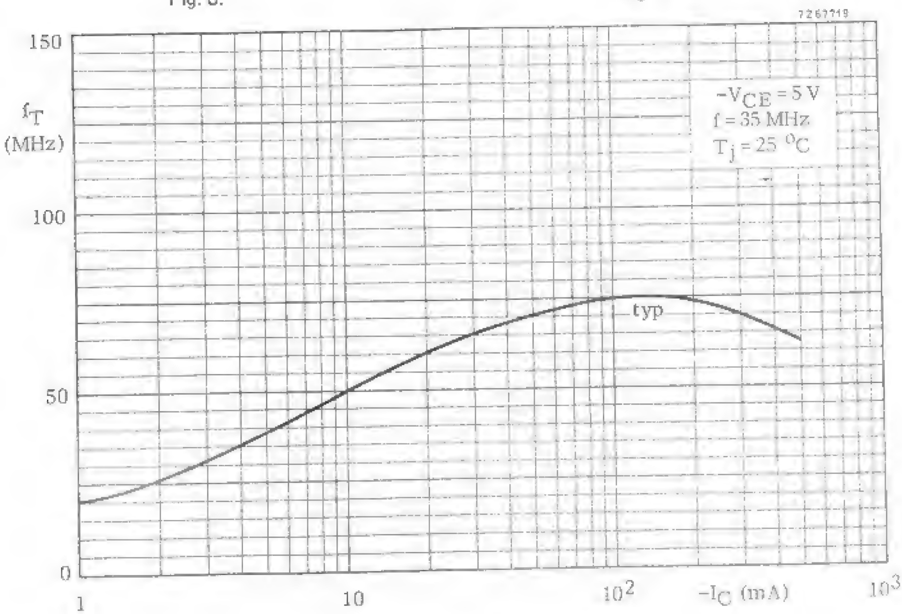


Fig. 8.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

They are intended for general purpose very high-gain low level and low-noise applications. Moreover, they are also suitable for low-speed switching applications.

QUICK REFERENCE DATA

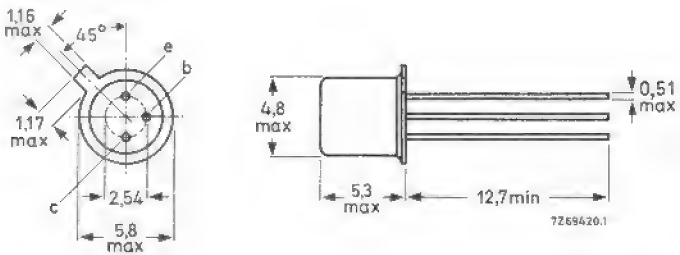
			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	V
Collector current (d.c.)	I_C	max.	100	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	mW
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	100	200	
		<	450	800	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ.	85	100	MHz
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15,7 kHz	F	typ.	1,5	1,5	dB
		<	5,0	5,0	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories 56246 (distance disc).

Products approved to CECC 50 002-164, available on request.

RATINGS (Limiting values) [1])

Voltages

			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	100	nA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	100	nA

Base-emitter voltage [2])

$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	650	mV
			600 to 700	mV

Collector-emitter saturation voltage

I_C = 10 mA; I_B = 1 mA	V_{CEsat}	typ.	80	mV
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	typ.	200	mV

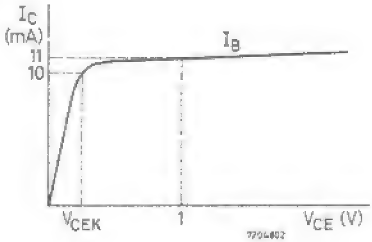
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[2]) V_{BE} decreases with about 2 mV/°C at increasing temperature.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



			BCY56	BCY57	
D.C. current gain					
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	h_{FE}	>	40	100	
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}	typ.	200	400	
			100 to 450	200 to 800	
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	>	100	200	
Transition frequency					
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	typ.	85	100	MHz
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	250	350	MHz
h parameters at f = 1 kHz					
$I_C = 2$ mA; $V_{CE} = 5$ V					
Input impedance	h_{ie}	typ.	3.5	7.5	kΩ
Reverse voltage transfer	h_{re}	typ.	1.75	3.5	10^{-4}
Small signal current gain	h_{fe}	typ.	250	500	
			125 to 500	240 to 900	
Output admittance	h_{oe}	typ.	17.5	35	$\mu\Omega^{-1}$
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	4.5	4.5	pF
Noise figure					
$I_C = 200\ \mu A$; $V_{CE} = 5$ V; $R_S = 2$ kΩ					
f = 30 Hz to 15.7 kHz	F	typ.	1.5	1.5	dB
		<	5	5	dB

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case, for use in amplifier and switching applications.

QUICK REFERENCE DATA

			BCY58	BCY59	
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Collector current (d.c.)	I_C	max.	200	200	mA
Total power dissipation					
up to T_{amb} = 45 °C	P_{tot}	max.	330	330	mW
up to T_{case} = 45 °C	P_{tot}	max.	1000	1000	mW
Junction temperature	T_j	max.	200	200	°C

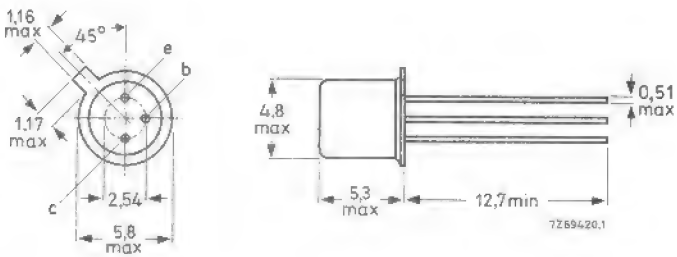
			BCY58–VII BCY59–VII	VIII VIII	IX IX	X X	
Small-signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	125 250	175 350	250 500	350 700	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.		280			MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 1 kHz; B = 200 Hz	F	typ.		2			dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories 56246 (distance disc).

Products approved to CECC 50 002-030/031, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BCY58	BCY59	
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V

Currents

Collector current	I_C	max.	200	mA
Base current	I_B	max.	50	mA

Power dissipation

Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	1000	mW

Temperatures

Storage temperature	T_{stg}	− 65	to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.45	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

CHARACTERISTICS $T_j = 25^{o}C$ unless otherwise specified

			BCY58	BCY59	
Collector cut-off currents					
$V_{CE} = 32$ V; $V_{BE} = 0$	I_{CES}	typ.	0.2		nA
		<	10		nA
$V_{CE} = 45$ V; $V_{BE} = 0$	I_{CES}	typ.		0.2	nA
		<		10	nA
$V_{CE} = 32$ V; $V_{BE} = 0$; $T_j = 150\,^{o}C$	I_{CES}	typ.	0.2		µA
		<	10		µA
$V_{CE} = 45$ V; $V_{BE} = 0$; $T_j = 150\,^{o}C$	I_{CES}	typ.		0.2	µA
		<		10	µA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	10	nA
Collector-emitter breakdown voltage					
$I_B = 0$; $I_C = 2$ mA	$V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0$; $I_E = 1\,\mu A$	$V_{(BR)EBO}$	>	7	7	V

Base emitter voltage				
$I_C = 10\,\mu A$; $V_{CE} = 5$ V	V_{BE}	typ.	0.5	V
$I_C = 20\,\mu A$; $V_{CE} = V_{CEO\,max}$; $T_j = 100\,^{o}C$	V_{BE}	>	0.2	V
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	0.62	V
			0.55 to 0.70	V
$I_C = 10$ mA; $V_{CE} = 1$ V	V_{BE}	typ.	0.70	V
$I_C = 100$ mA; $V_{CE} = 1$ V	V_{BE}	typ.	0.76	V
Saturation voltages				
$I_C = 10$ mA; $I_B = 0.25$ mA	V_{CEsat}	typ.	100	mV
			50 to 350	mV
	V_{BEsat}	typ.	700	mV
			600 to 850	mV
$I_C = 100$ mA; $I_B = 2.5$ mA	V_{CEsat}	typ.	250	mV
			150 to 700	mV
	V_{BEsat}	typ.	875	mV
			750 to 1200	mV

CHARACTERISTICS (continued) $T_j = 25\,^{o}C$ unless otherwise specified

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	3.0	pF
		<	5.0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	10	pF
		<	15	pF
Transition frequency at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	>	150	MHz
		typ.	280	MHz
Noise figure at $R_S = 2$ kΩ				
$I_C = 200$ μA; $V_{CE} = 5$ V				
f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	6	dB

			BCY58VII BCY59VII	BCY58VIII BCY59VIII	BCY58IX BCY59IX	BCY58X BCY59X	
D.C. current gain							
$I_C = 10$ μA; $V_{CE} = 5$ V	h_{FE}	>	–	20	40	100	
		typ.	20	95	190	300	
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}	>	120	180	250	380	
		typ.	170	250	350	500	
		<	220	310	460	630	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	80	120	160	240	
		typ.	250	300	390	550	
		<	–	400	630	1000	
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	45	60	60	
h parameters at f = 1 kHz							
$I_C = 2$ mA; $V_{CE} = 5$ V							
Input impedance	h_{ie}	>	1.6	2.5	3.2	4.5	kΩ
		typ.	2.7	3.6	4.5	7.5	kΩ
		<	4.5	6.0	8.5	12	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	3	10^{-4}
Small signal current gain	h_{fe}	>	125	175	250	350	
		typ.	200	260	330	520	
		<	250	350	500	700	
Output admittance	h_{oe}	typ.	18	24	30	50	μA/V
		<	30	50	60	100	μA/V

CHARACTERISTICS (continued)

Switching times

I_C = 10 mA; I_B = 1 mA; $-I_{BM}$ = 1 mA

R1 = 5 kΩ; R2 = 5 kΩ; R_L = 990 Ω

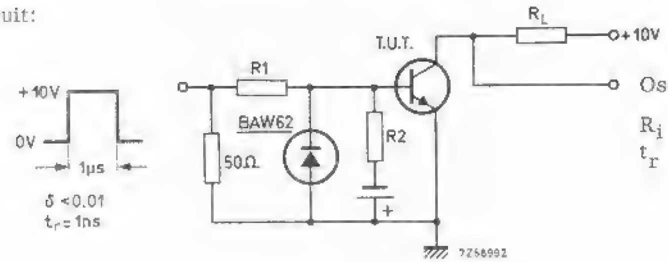
V_{BB} = 3.6 V	delay time	t_d	typ.	35	ns
	rise time	t_r	typ.	50	ns
	turn on time	t_{on}	typ.	85	ns
			<	150	ns
	storage time	t_s	typ.	400	ns
	fall time	t_f	typ.	80	ns
	turn off time	t_{off}	typ.	480	ns
			<	800	ns

I_C = 100 mA; I_B = 10 mA; $-I_{BM}$ = 10 mA

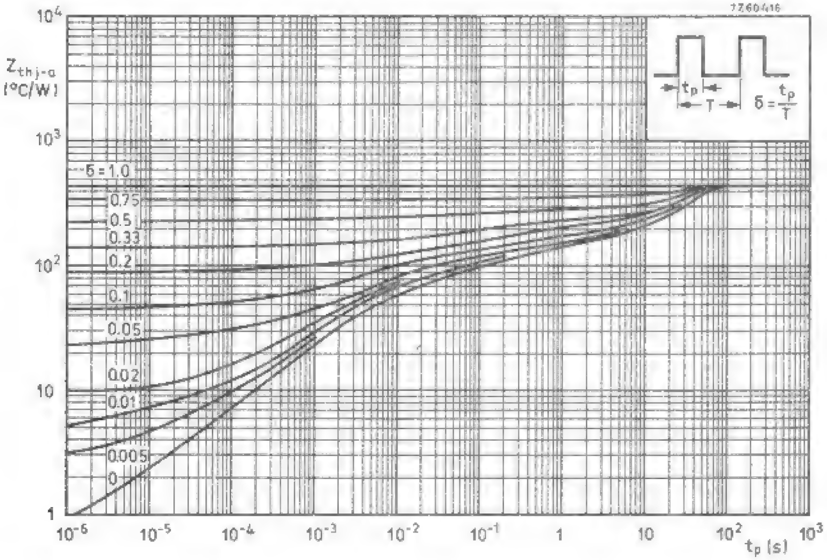
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω

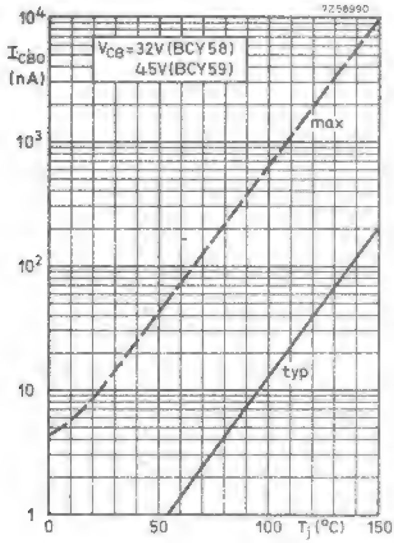
V_{BB} = 5 V	delay time	t_d	typ.	5	ns
	rise time	t_r	typ.	50	ns
	turn on time	t_{on}	typ.	55	ns
			<	150	ns
	storage time	t_s	typ.	250	ns
	fall time	t_f	typ.	200	ns
	turn off time	t_{off}	typ.	450	ns
			<	800	ns

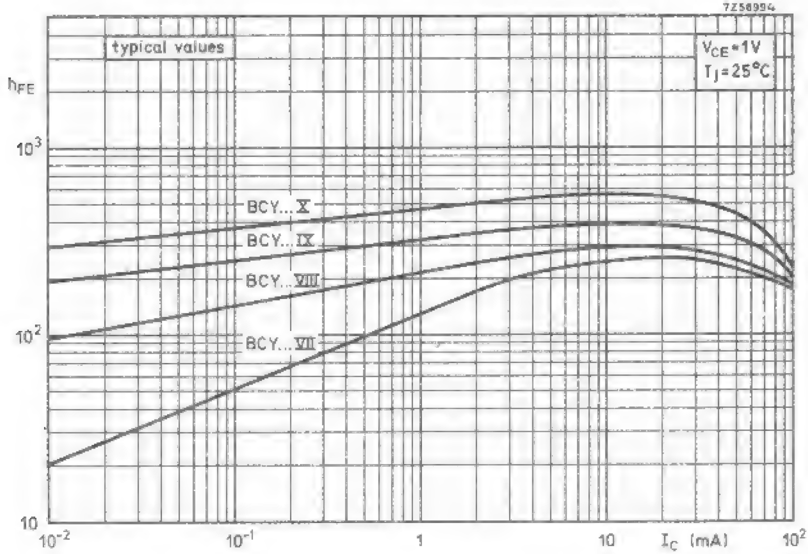
Test circuit:

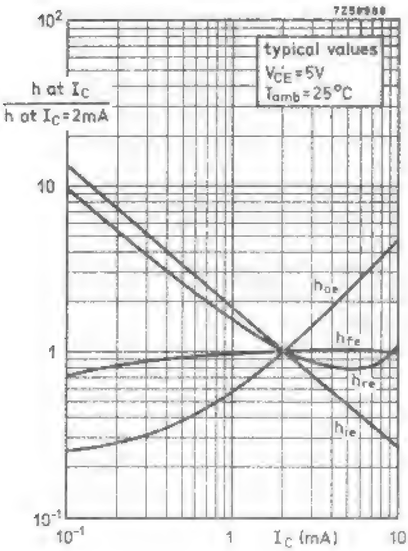


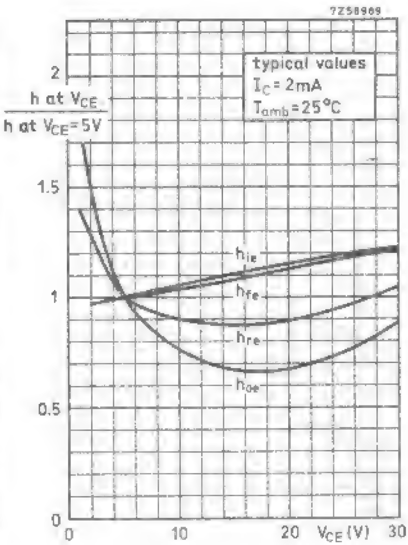
Oscilloscope:
R_i > 100 kΩ
t_r < 15 ns

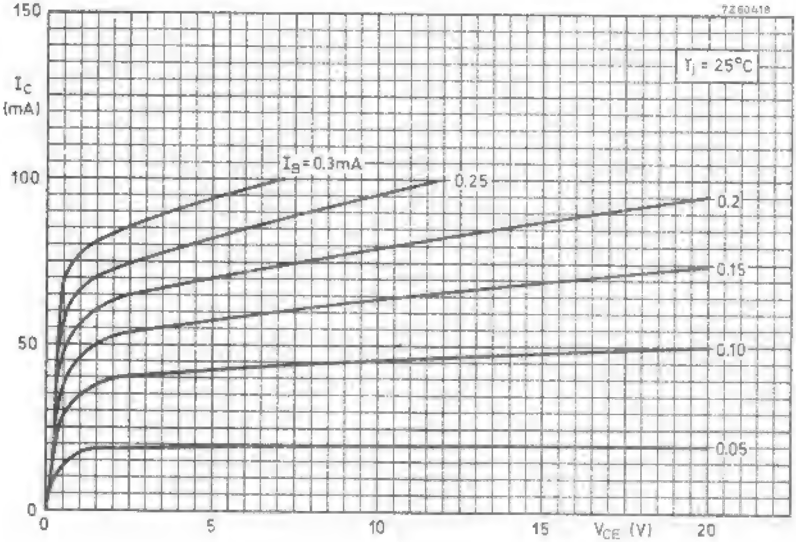

7Z60416
$Z_{th\,j\text{-}a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0.005
0
t_p (s)

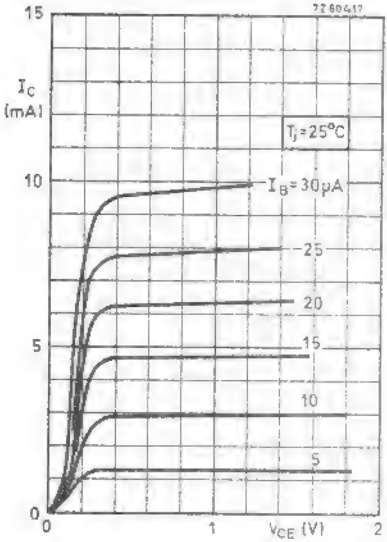

7Z58990
I_{CBO} (nA)
V_{CB} = 32V (BCY58)
45V (BCY59)
max
typ
T_j (°C)

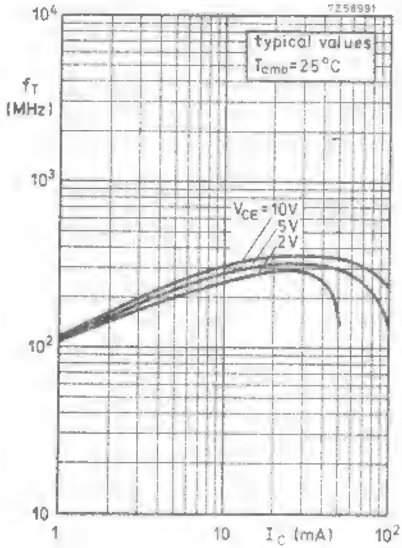

7Z58994
typical values
V_{CE} = 1V
T_j = 25°C
h_{FE}
BCY... X
BCY... IX
BCY... VIII
BCY... VII
I_C (mA)

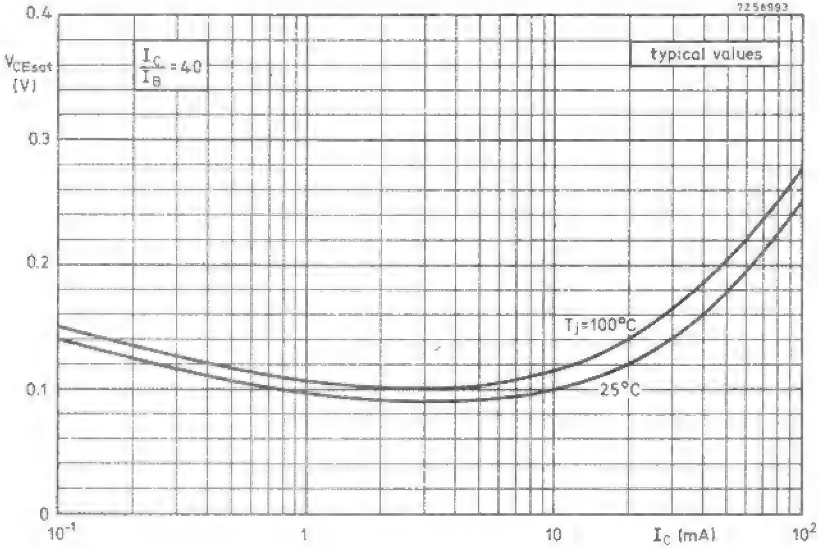

typical values
V_{CE} = 5V
T_{amb} = 25°C
h at I_C / h at I_C = 2mA
h_{oe}
h_{fe}
h_{re}
h_{ie}
I_C (mA)

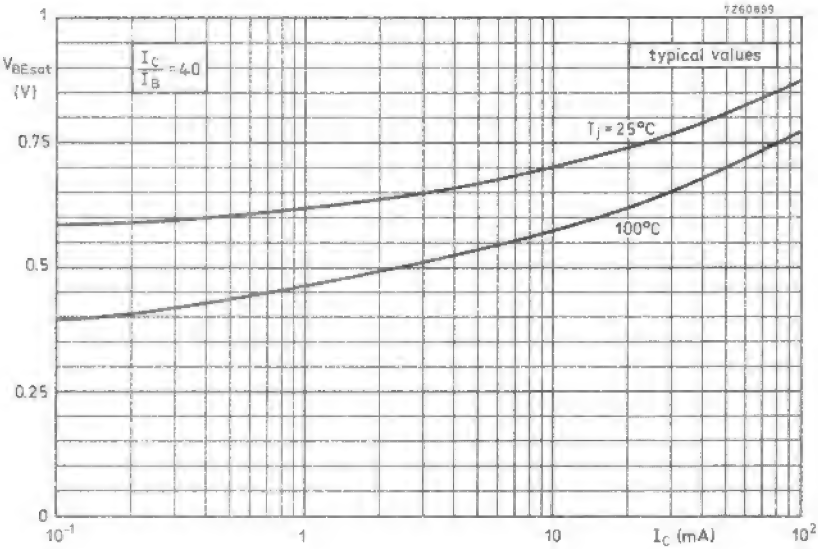

7Z58969
typical values
I_C = 2mA
T_{amb} = 25°C
h at V_{CE} / h at V_{CE} = 5V
h_{ie}
h_{fe}
h_{re}
h_{oe}
V_{CE} (V)

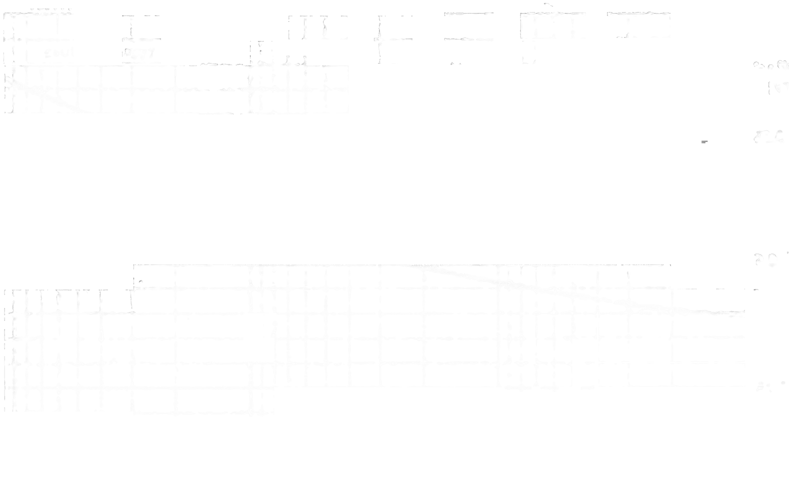

7Z60418
$T_j = 25°C$
I_C (mA)
$I_B = 0.3mA$
0.25
0.2
0.15
0.10
0.05
150
100
50
0
0
5
10
15
20
V_{CE} (V)


7Z60417
I_C (mA)
$T_j = 25°C$
$I_B = 30μA$
25
20
15
10
5
15
10
5
0
0
1
2
V_{CE} (V)


7Z58991
typical values
$T_{amb} = 25°C$
f_T (MHz)
$V_{CE} = 10V$
5V
2V
10^4
10^3
10^2
10
1
10
I_C (mA)
10^2


7Z58993
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 40$
typical values
$T_j = 100\,^{\circ}C$
$25\,^{\circ}C$
I_C (mA)
0.4
0.3
0.2
0.1
0
10^{-1}
1
10
10^2


7Z60899
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 40$
typical values
$T_j = 25\,^{\circ}C$
$100\,^{\circ}C$
I_C (mA)
1
0.75
0.5
0.25
0
10^{-1}
1
10
10^2



SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes intended for general purpose industrial applications. The BCY71 is a low noise version.

QUICK REFERENCE DATA

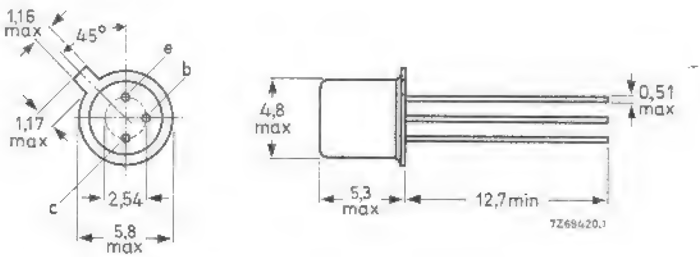
			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Junction temperature	T_j	max.		200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>		100		
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>		250		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-079/081, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0	5,0	5,0	V
Collector current (d.c.)	$-I_C$	max.		200		mA
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Emitter current (peak value)	I_{EM}	max.		200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Storage temperature	T_{stg}			−65 to + 200		°C
Junction temperature	T_j	max.		200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	500	K/W
From junction to case	$R_{th\,j\text{-}c}$	=	150	K/W

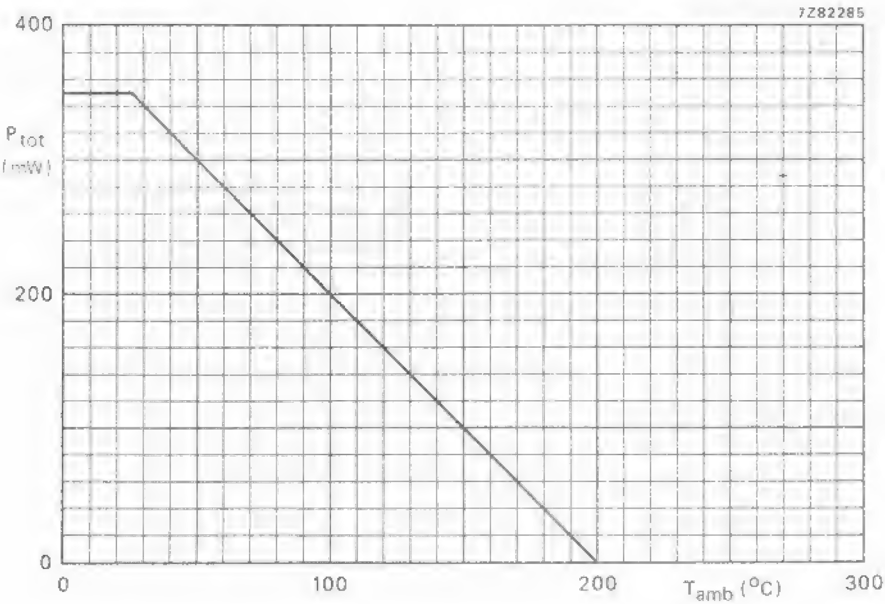


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCY70	BCY71	BCY72	
Collector cut-off current						
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	typ.	10	10	10	nA
		<	500	500	500	nA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	typ.	0,5	0,5	–	nA
		<	10	50	–	nA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	0,1	0,1	–	µA
		<	0,5	2,0	–	µA
$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	typ.	–	–	0,5	nA
		<	–	–	50	nA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	–	–	0,1	µA
		<	–	–	2,0	µA
$-V_{CE} = 50$ V; $-V_{EB} = 3{,}0$ V	$-I_{CEX}$	typ.	1,0	–	–	nA
		<	20	–	–	nA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 4{,}0$ V	$-I_{EBO}$	typ.		0,3		nA
		<		10		nA
$I_C = 0$; $-V_{EB} = 4{,}0$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.		20		nA
		<		2,0		µA
$I_C = 0$; $-V_{EB} = 5{,}0$ V	$-I_{EBO}$	typ.		5,0		nA
		<		500		nA
Saturation voltages						
$-I_C = 10$ mA; $-I_B = 1{,}0$ mA	$-V_{CEsat}$	typ.		95		mV
		<		250		mV
	$-V_{BEsat}$	typ.		750		mV
				600 to 900		mV
$-I_C = 50$ mA; $-I_B = 5{,}0$ mA	$-V_{CEsat}$	typ.		190		mV
		<		500		mV
	$-V_{BEsat}$	typ.		860		mV
		<		1200		mV
Knee voltage (see Fig. 3)						
$-I_C = 10$ mA; $-I_B$ = value for which $-I_C = 11$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	typ.		270		mV
		<		600		mV

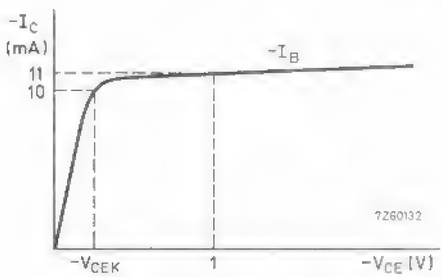


Fig. 3.

D.C. current gain					
$-I_C = 10\ \mu A$; $-V_{CE} = 1,0\ V$		h_{FE}	>	60	
			typ.	245	
$-I_C = 0,1\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	80	
			typ.	270	
$-I_C = 1,0\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	100	
			typ.	300	
$-I_C = 10\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	100	
			typ.	290	
$-I_C = 10\ mA$; $-V_{CE} = 1,0\ V$	**BCY71**	h_{FE}	<	400	
$-I_C = 50\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	45	
			typ.	175	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 10\ V$		C_c	typ.	4,5	pF
			<	6,0	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = 1,0\ V$		C_e	typ.	6,0	pF
			<	8,0	pF

			BCY70	BCY71	BCY72	
Transition frequency at $T_{amb} = 25\ ^oC$						
$-I_C = 10\ mA$; $-V_{CE} = 20\ V$; f = 100 MHz	f_T	>	250	250	250	MHz
		typ.	450	450	450	MHz
$-I_C = 100\ \mu A$; $-V_{CE} = 20\ V$; f = 10,7 MHz	f_T	>	–	15	–	MHz
		typ.	–	30	–	MHz
Noise figure						
$-I_C = 100\ \mu A$; $-V_{CE} = 5,0\ V$						
f = 10 Hz to 10 kHz; $R_S = 2,0\ k\Omega$	F	typ.	2,0	0,8	2,0	dB
		<	6,0	2,0	6,0	dB
h-parameters (common emitter)						
$-I_C = 1,0\ mA$; $-V_{CE} = 10\ V$; f = 1 kHz;						
$T_{amb} = 25\ ^oC$		>	–	2,0	–	kΩ
Input impedance	h_{ie}	typ.	–	4,0	–	kΩ
		<	–	12,0	–	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	–	2,1	–	10^{-4}
		<	–	20,0	–	10^{-4}
		>	–	150	–	
Small-signal current gain	h_{fe}	typ.	–	325	–	
		<	–	400	–	
		>	–	10	–	μA/V
Output admittance	h_{oe}	typ.	–	20	–	μA/V
		<	–	60	–	μA/V

Switching times of the **BCY70** and **BCY72**.

$-I_C = 10$ mA; $-I_{Bon} = +I_{Boff} = 1$ mA

delay time	t_d	typ.	23 ns
		<	35 ns
rise time	t_r	typ.	25 ns
		<	35 ns
turn-on time	t_{on}	typ.	48 ns
		<	65 ns
storage time	t_s	typ.	270 ns
		<	350 ns
fall time	t_f	typ.	50 ns
		<	80 ns
turn-off time	t_{off}	typ.	320 ns
		<	420 ns

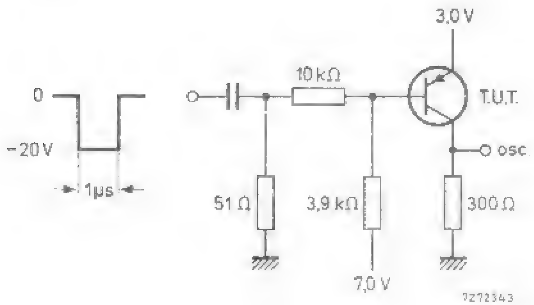


Fig. 4 Test circuit.

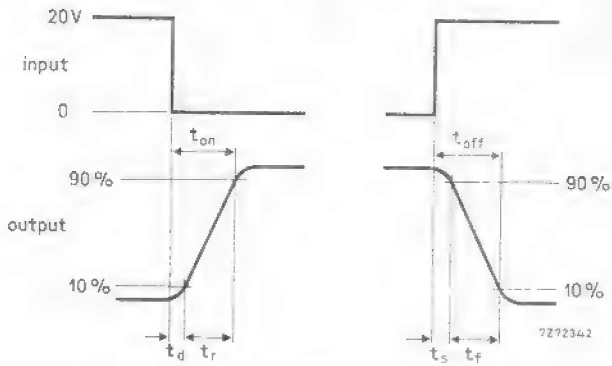


Fig. 5 Switching waveforms.

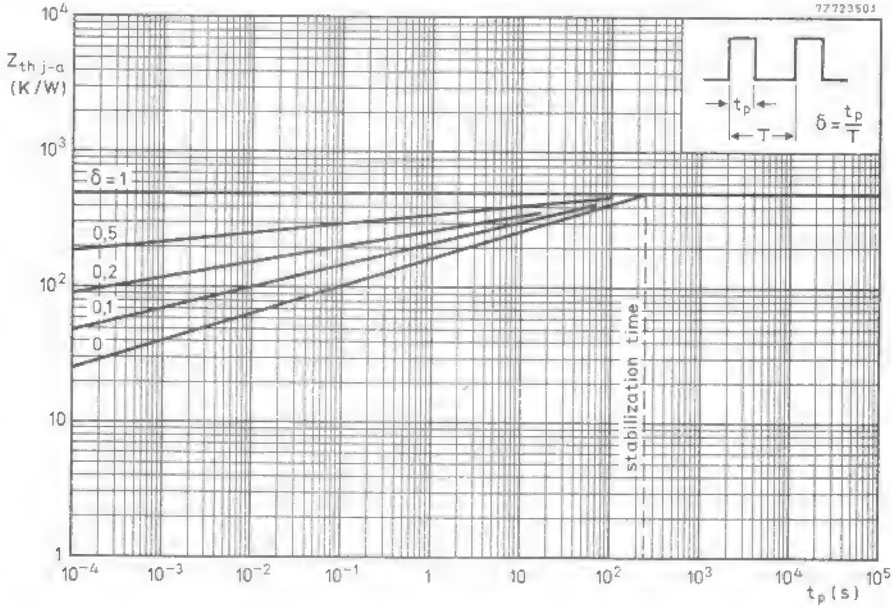

7Z72350i
$Z_{th\ j-a}$ (K/W)
$\delta = 1$
0,5
0,2
0,1
0
stabilization time
t_p
T
$\delta = \frac{t_p}{T}$
10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 10^3 10^4 10^5
t_p (s)
10^4 10^3 10^2 10 1

Fig. 6.

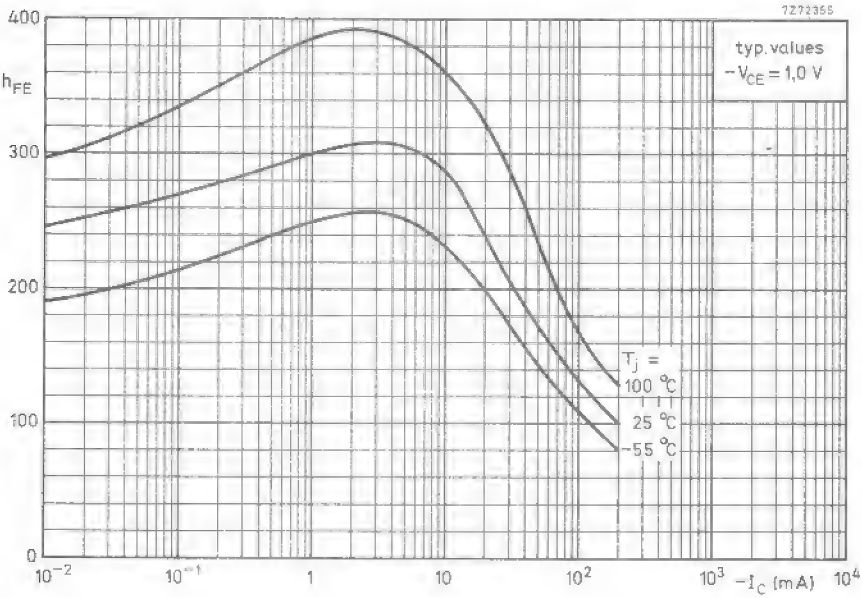

7Z72355
typ. values
$-V_{CE} = 1{,}0$ V
h_{FE}
400 300 200 100 0
T_j =
100 °C
25 °C
−55 °C
10^{-2} 10^{-1} 1 10 10^2 10^3 10^4
$-I_C$ (mA)

Fig. 7.

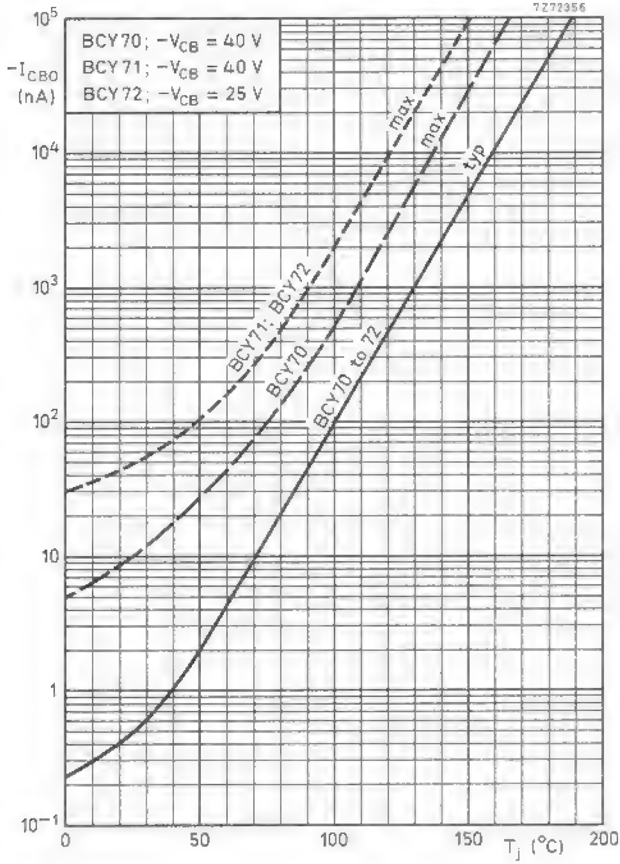

7Z72356
BCY70; $-V_{CB}$ = 40 V
BCY71; $-V_{CB}$ = 40 V
BCY72; $-V_{CB}$ = 25 V
$-I_{CBO}$ (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
max
typ
BCY71; BCY72
BCY70
BCY70 to 72
0
50
100
150
T_j (°C)
200

Fig. 8.

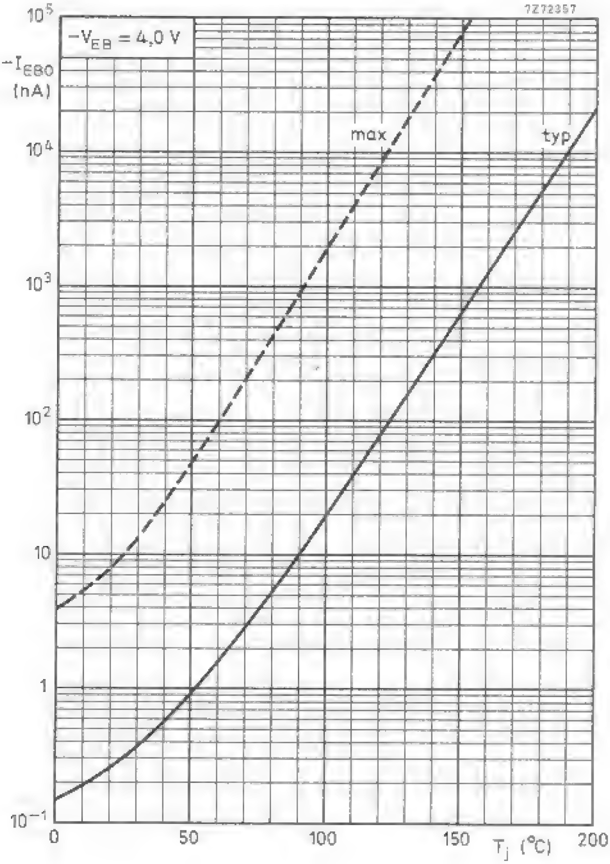

7Z72357
$-V_{EB} = 4,0$ V
$-I_{EBO}$ (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
typ
0
50
100
150
200
T_j (°C)

Fig. 9.

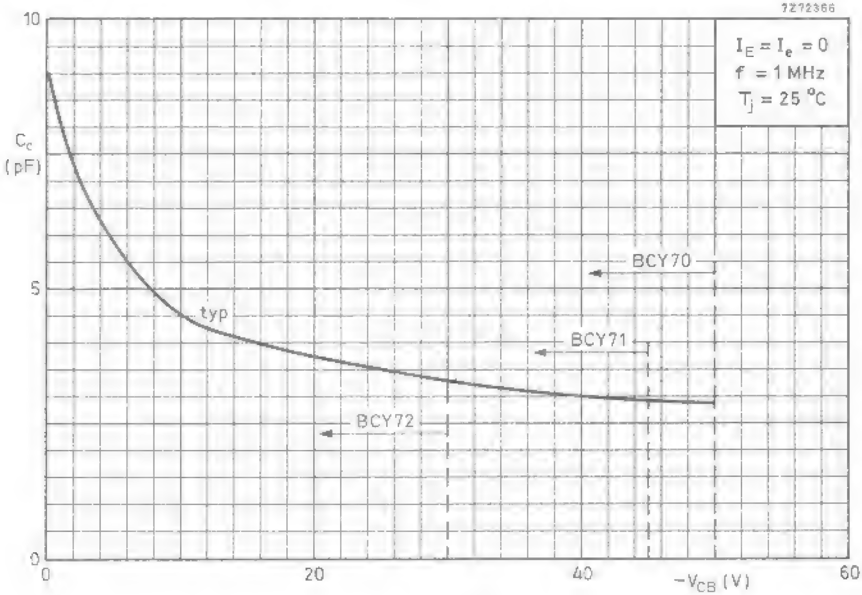

7Z72366
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
BCY70
BCY71
BCY72
typ
$-V_{CB}$ (V)
10
5
0
0
20
40
60

Fig. 10.

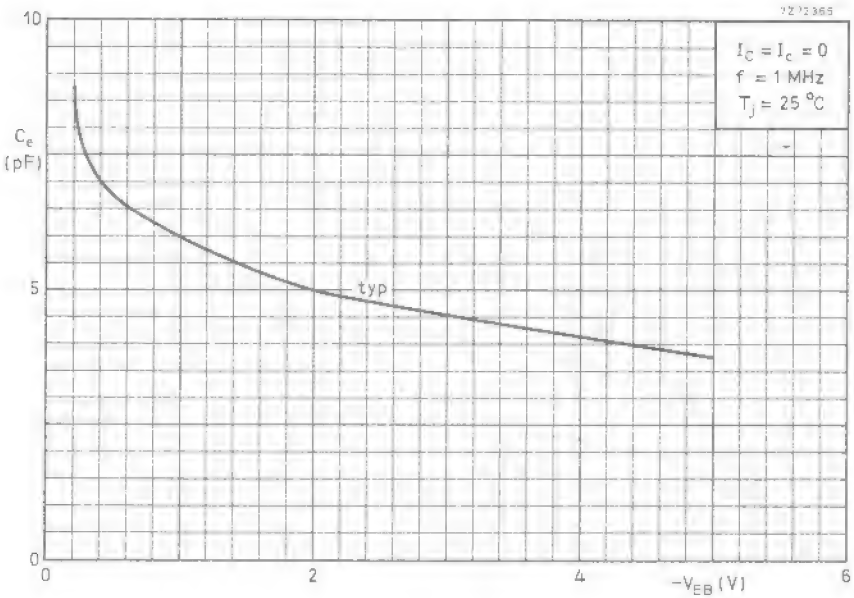

7Z72365
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
typ
$-V_{EB}$ (V)
10
5
0
0
2
4
6

Fig. 11.

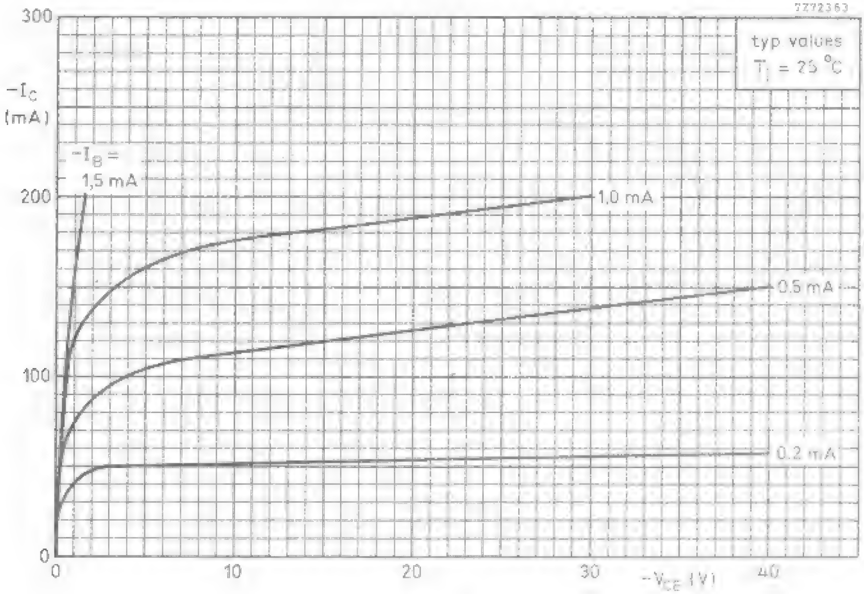

7Z72363
typ values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
10
20
30
40
$-V_{CE}$ (V)

Fig. 12.

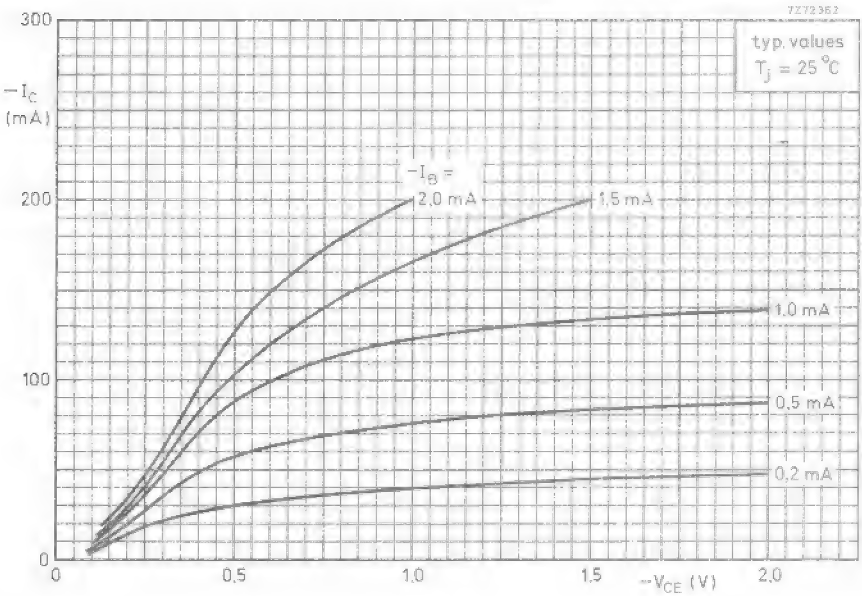

7Z72362
typ. values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 2,0 mA
1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
0,5
1,0
1,5
2,0
$-V_{CE}$ (V)

Fig. 13.

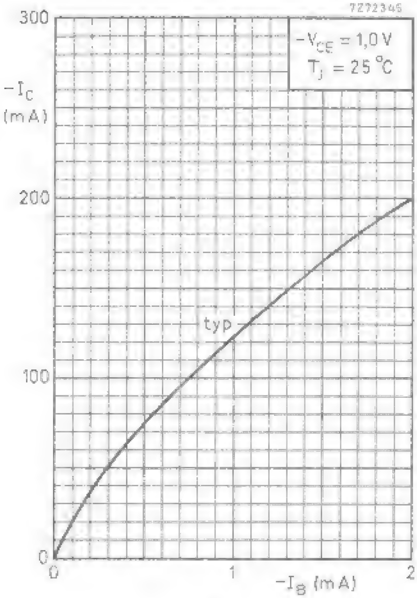


Fig. 14.

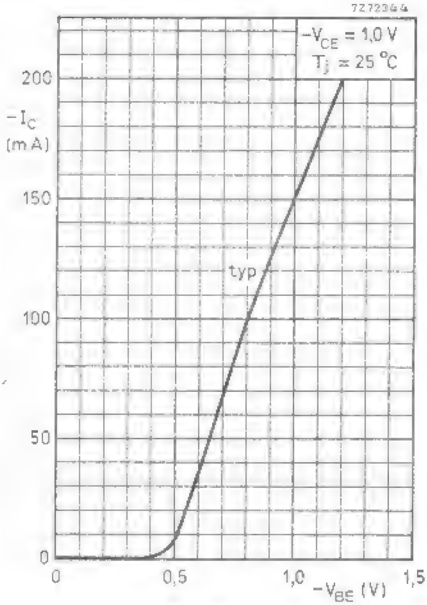


Fig. 15.

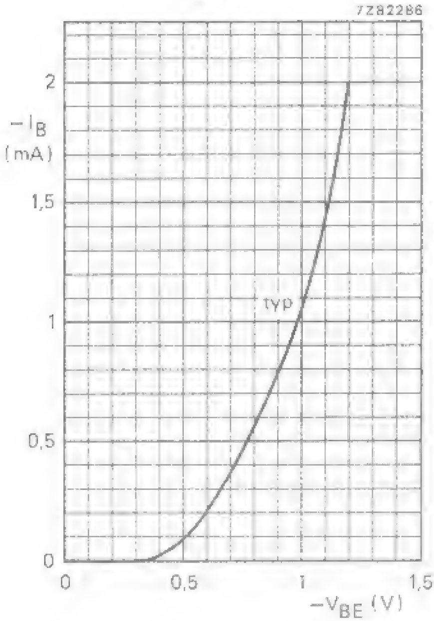


Fig. 16 $-V_{CE}$ = 1,0 V; T_j = 25 °C

Fig. 17 $-V_{CE}$ = 20 V; f = 100 MHz; T_{amb} = 25 °C.

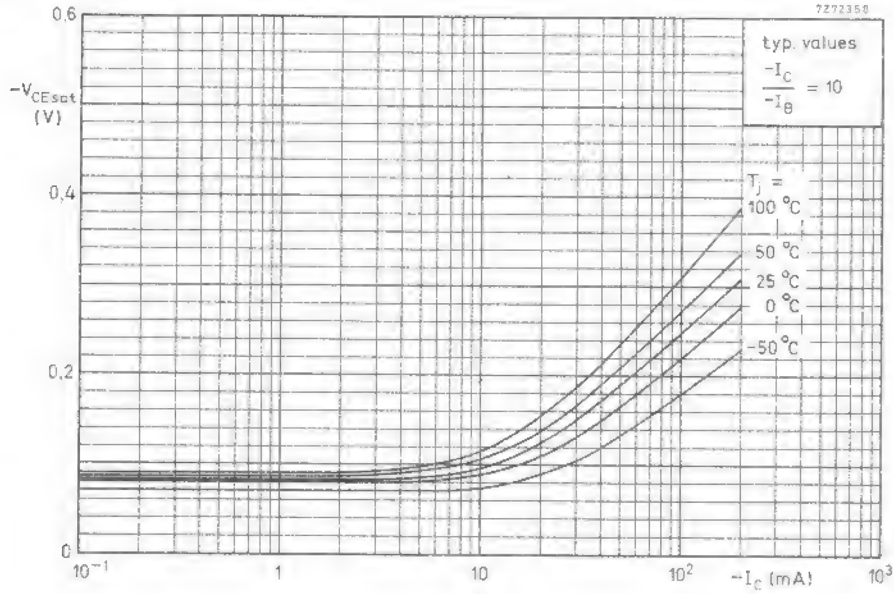

7Z72358
typ. values
$\frac{-I_C}{-I_B} = 10$
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
$T_j =$
100 °C
50 °C
25 °C
0 °C
−50 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 18.

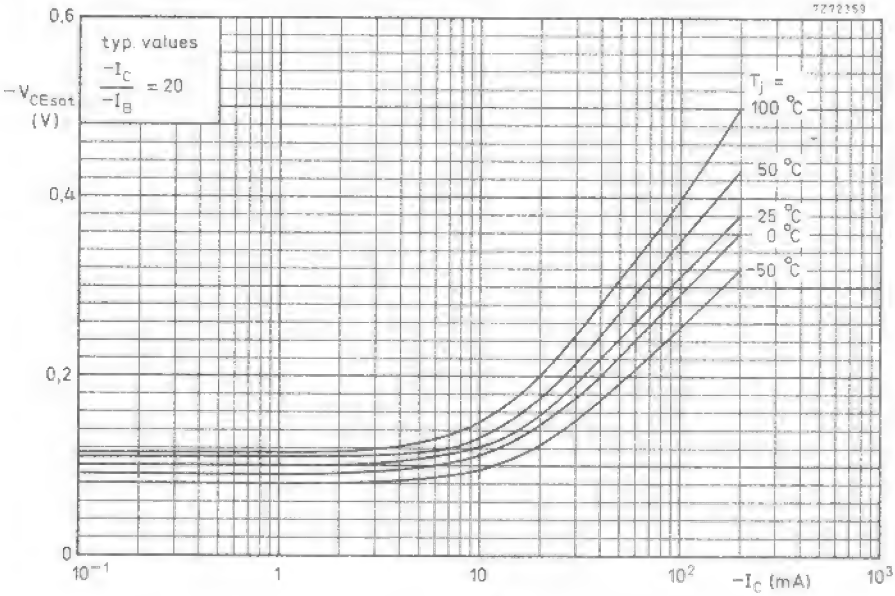

7Z72359
typ. values
$\frac{-I_C}{-I_B} = 20$
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
$T_j =$
100 °C
50 °C
25 °C
0 °C
−50 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 19.

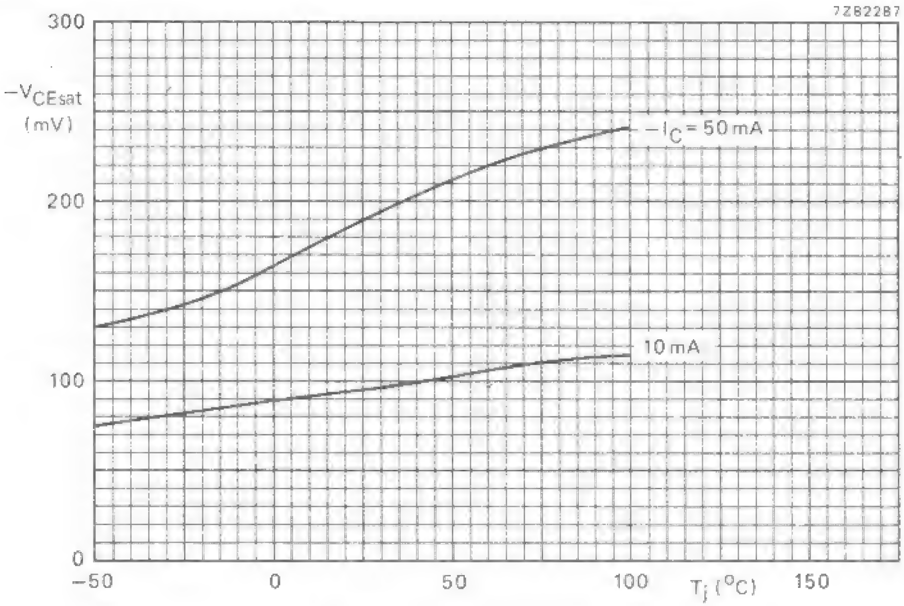


Fig. 20 $-I_C/-I_B$ = 10; typical values.

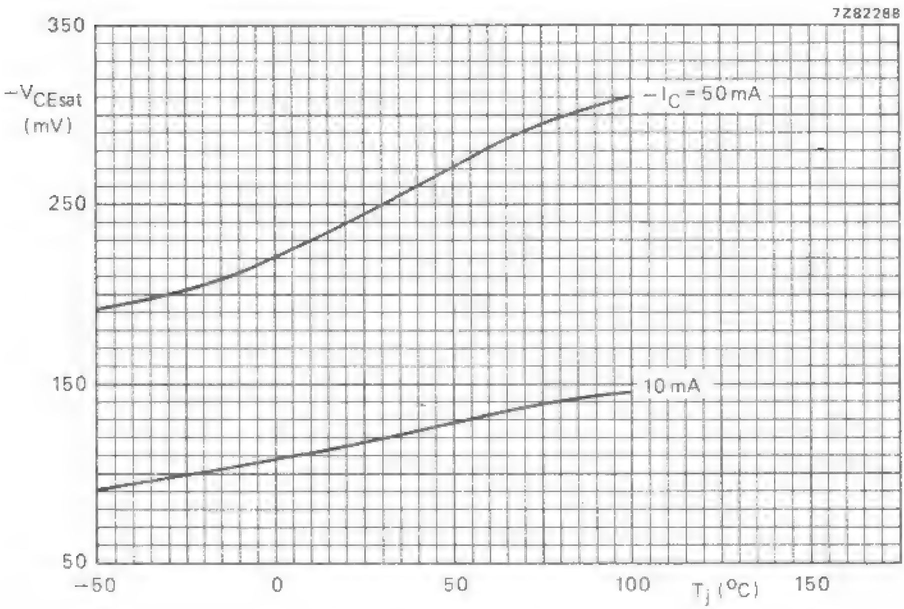


Fig. 21 $-I_C/-I_B$ = 20; typical values.

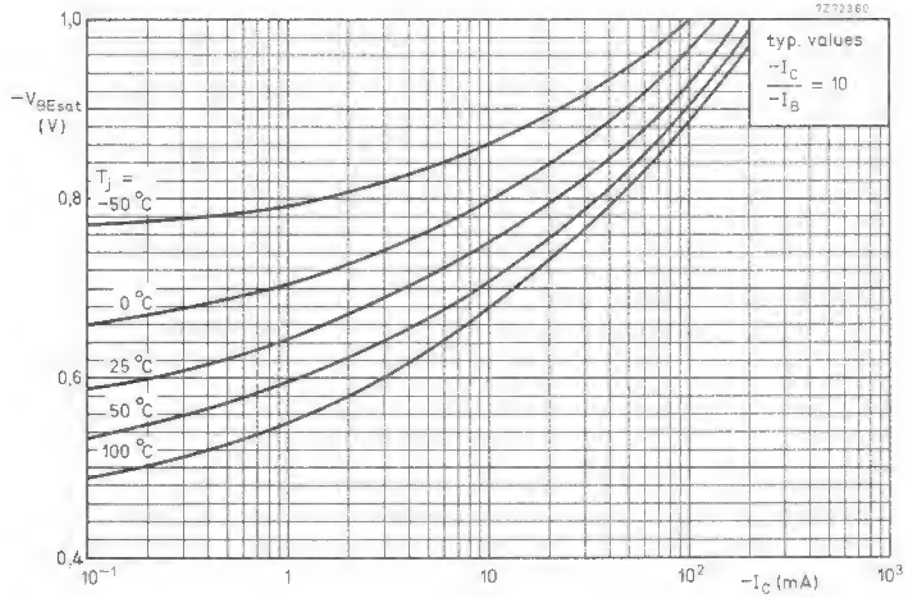

7Z72360
1,0
0,8
0,6
0,4
$-V_{BEsat}$ (V)
T_j = −50 °C
0 °C
25 °C
50 °C
100 °C
typ. values
$\frac{-I_C}{-I_B} = 10$
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 22.

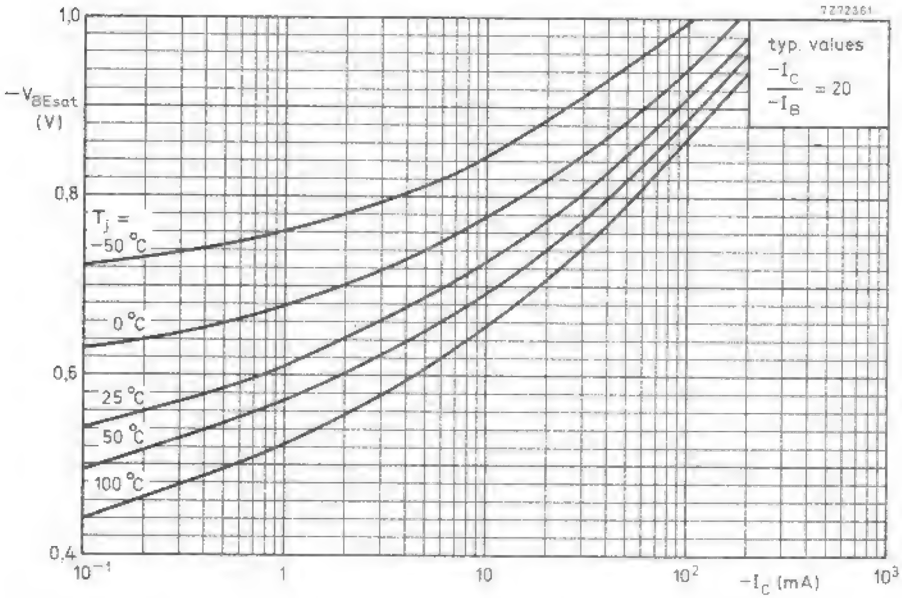

7Z72361
1,0
0,8
0,6
0,4
$-V_{BEsat}$ (V)
T_j = −50 °C
0 °C
25 °C
50 °C
100 °C
typ. values
$\frac{-I_C}{-I_B} = 20$
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 23.

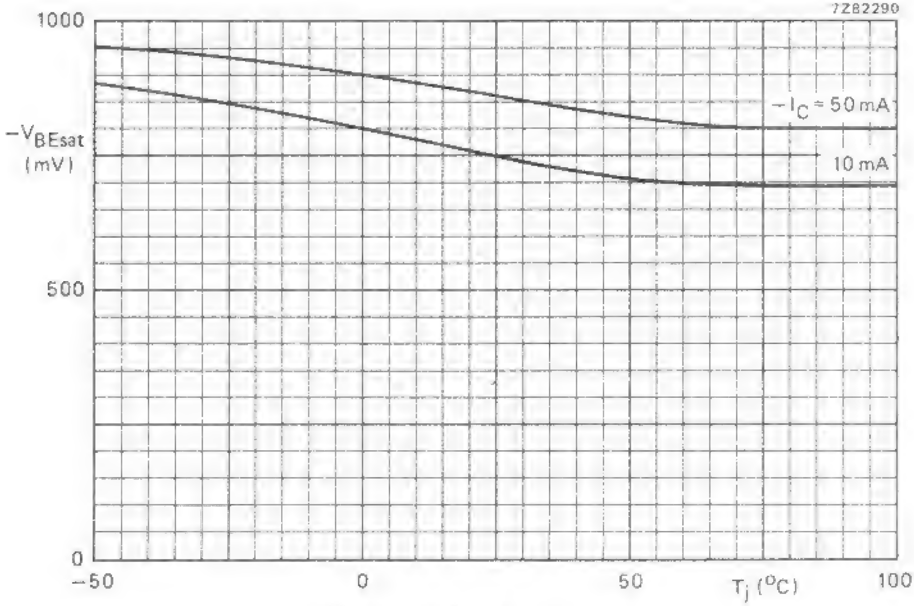


Fig. 24 $-I_C/-I_B = 10$; typical values.

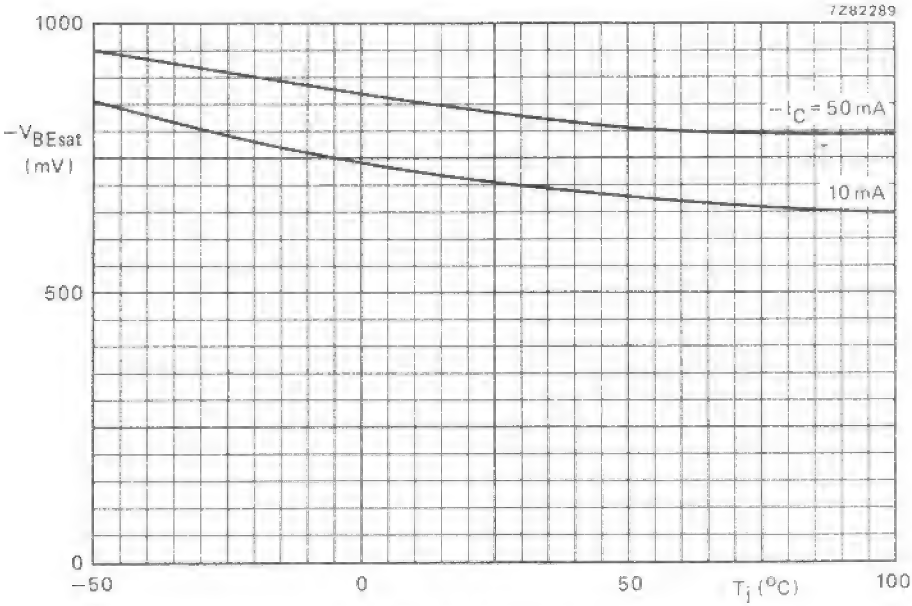


Fig. 25 $-I_C/-I_B = 20$; typical values.

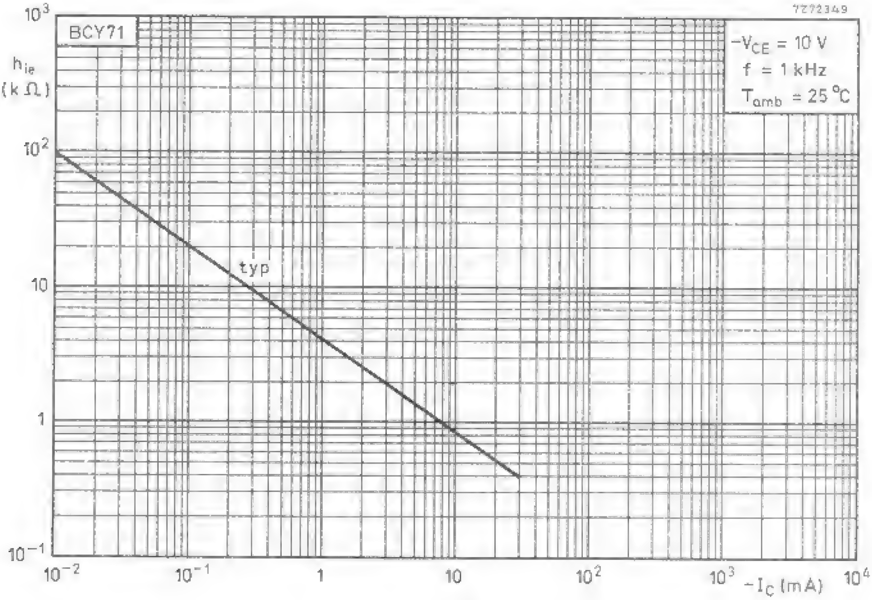

7Z72349
BCY71
h_{ie}
(kΩ)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 26.

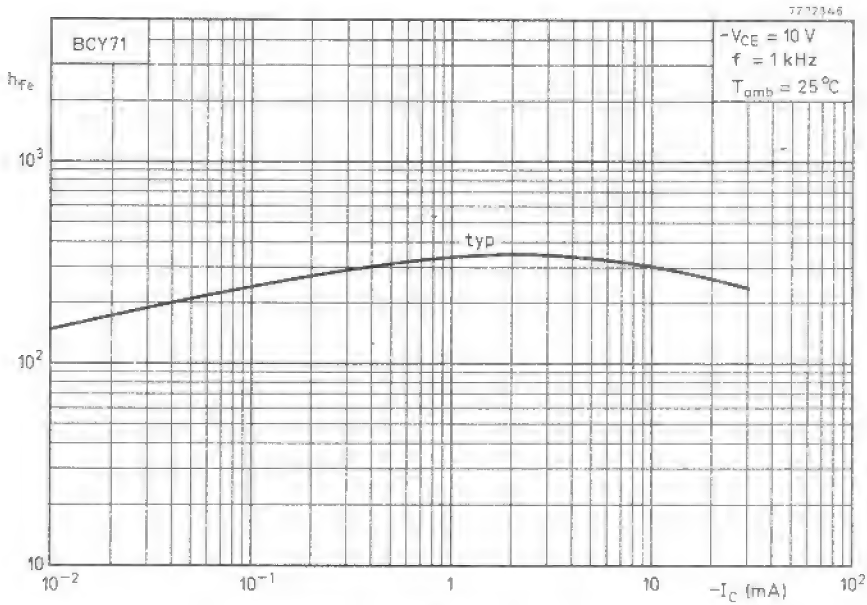

7Z72346
BCY71
h_{fe}
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 27.

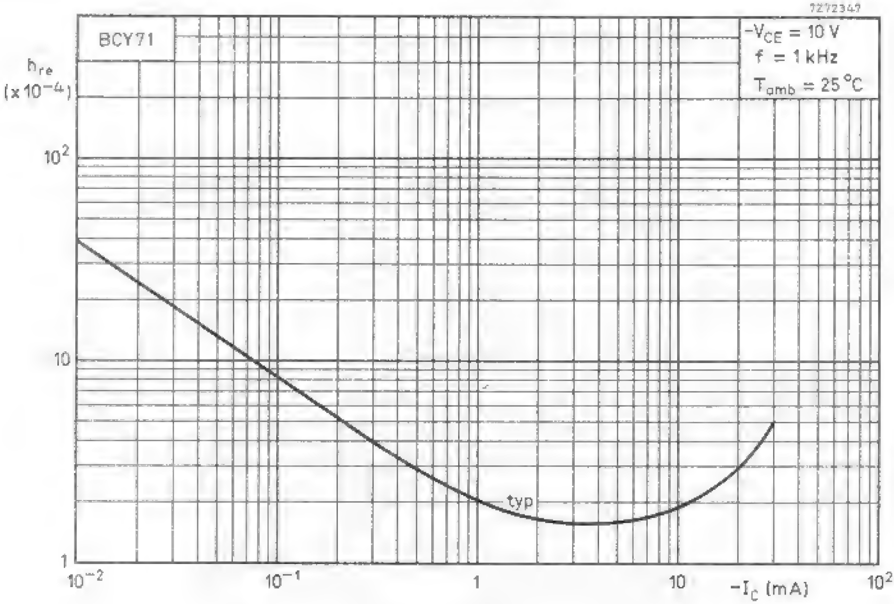

7Z72347
BCY71
h_{re}
$(\times 10^{-4})$
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
10^2
10
1
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 28.

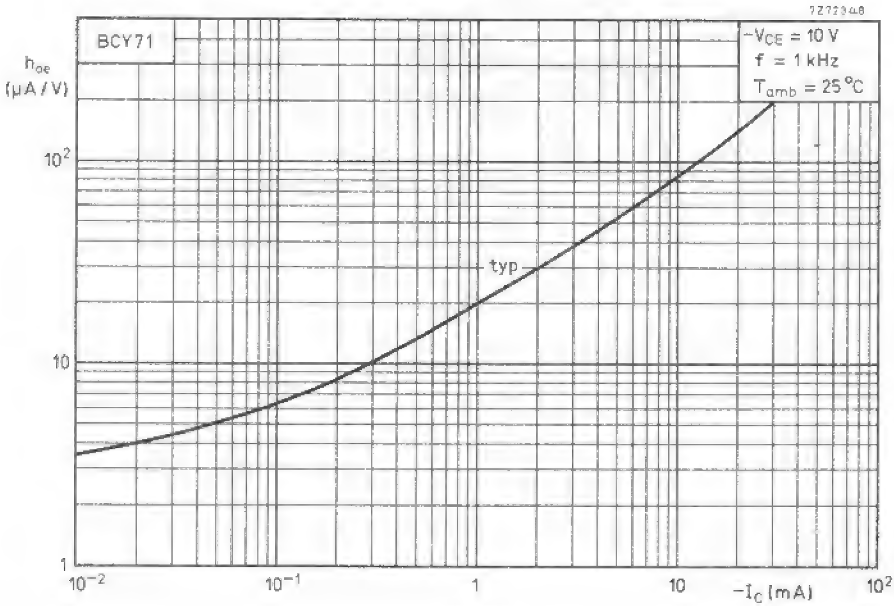

7Z72348
BCY71
h_{oe}
(μA / V)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
10^2
10
1
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 29.

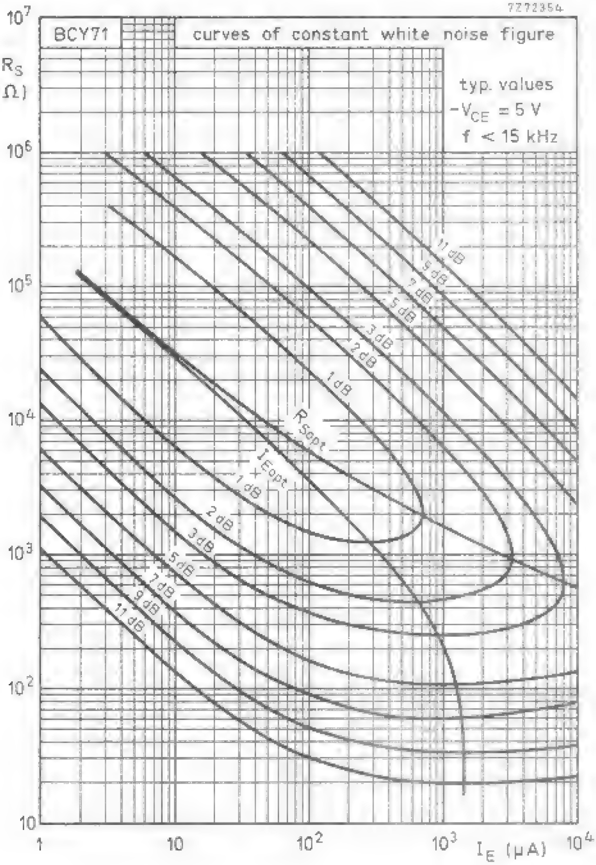


Fig. 30.

See also the graph and text on next page.

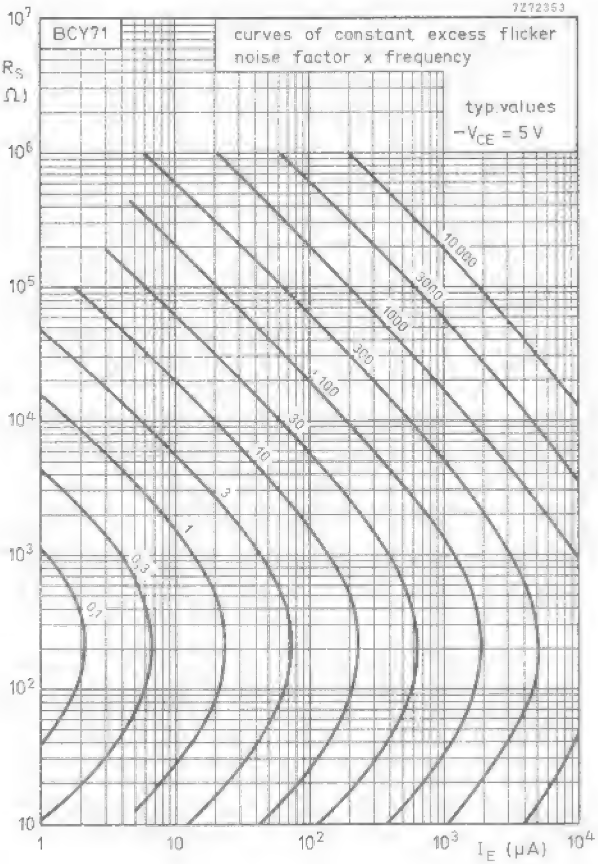


Fig. 31.

Determination of total noise figure

Total noise at f < 15 kHz includes flicker noise and white noise.

The relationship is as follows: noise factor = 1 + flicker noise factor + white noise factor.

The flicker noise factor can be derived from the curves of the graph above, the white noise factor from the curves of the graph on preceding page.

Example:

Assume a BCY71 operating at f = 200 Hz; I_E = 200 μA with a source resistance R_S = 10 kΩ. From the graph on this page it follows that at I_E = 200 μA with R_S = 10 kΩ the product of frequency and flicker noise factor is 110. Since the frequency is 200 Hz, the flicker noise factor is 110/200 = 0,55. It follows that at I_E = 200 μA with R_S = 10 kΩ the white noise figure is 0,9 dB, representing a factor of 1,23. Thus the total noise factor = 0,55 + 1,23 = 1,78 or 2,5 dB.

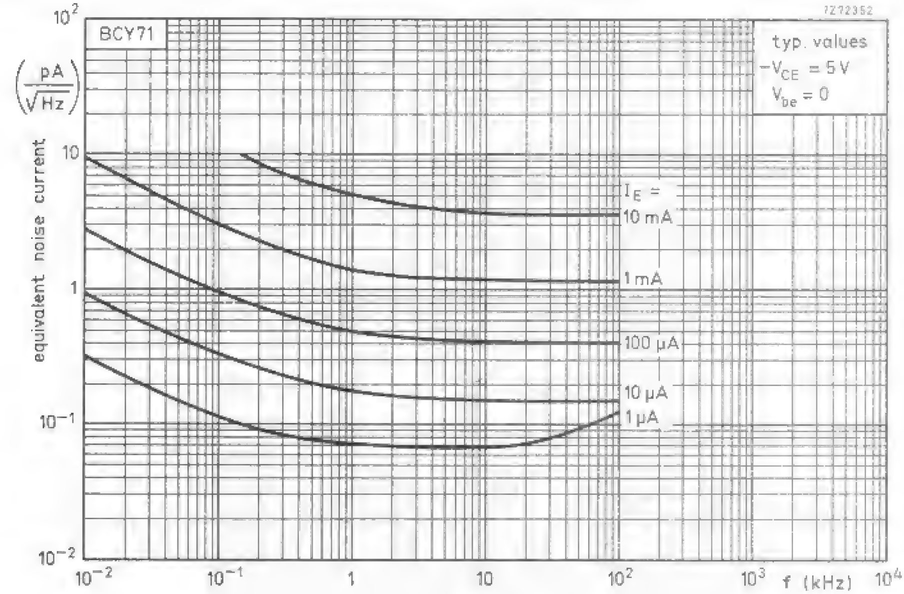

7Z72352
BCY71
typ. values
$-V_{CE} = 5\ V$
$V_{be} = 0$
$\left(\frac{pA}{\sqrt{Hz}}\right)$
equivalent noise current
$I_E =$
10 mA
1 mA
100 μA
10 μA
1 μA
f (kHz)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4

Fig. 32.

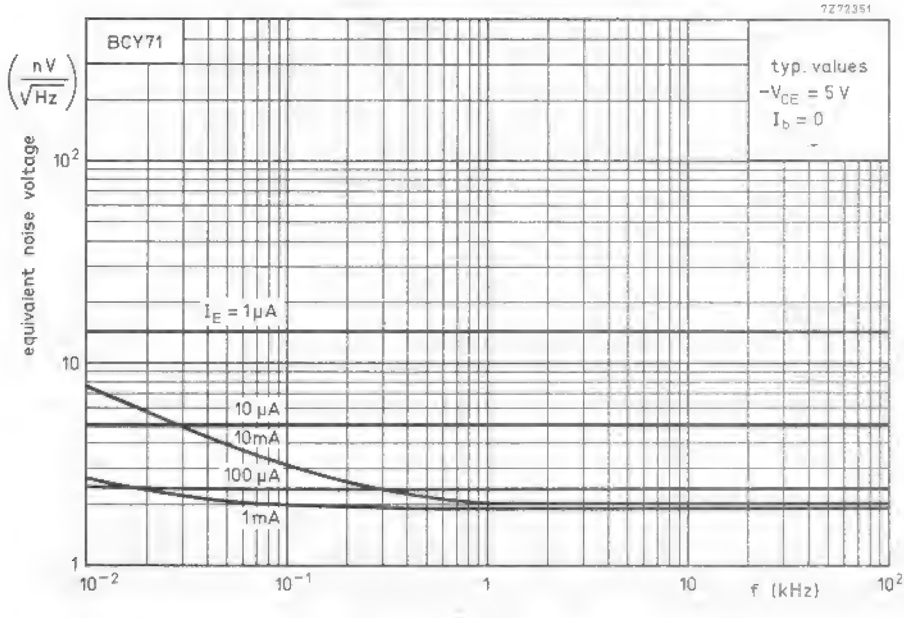

7Z72351
BCY71
typ. values
$-V_{CE} = 5\ V$
$I_b = 0$
$\left(\frac{nV}{\sqrt{Hz}}\right)$
equivalent noise voltage
$I_E = 1\ \mu A$
10 μA
10mA
100 μA
1mA
f (kHz)
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2

Fig. 33.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes, intended for use in amplifier and switching applications.

QUICK REFERENCE DATA

			BCY78	BCY79	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Collector current (d.c.)	$-I_C$	max.	200		mA
Total power dissipation					
up to T_{amb} = 45 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		mW
Junction temperature	T_j	max.	200		°C

			BCY78–VII BCY79–VII	VIII VIII	IX IX	X
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	> <	125 250	175 350	250 500	350 700

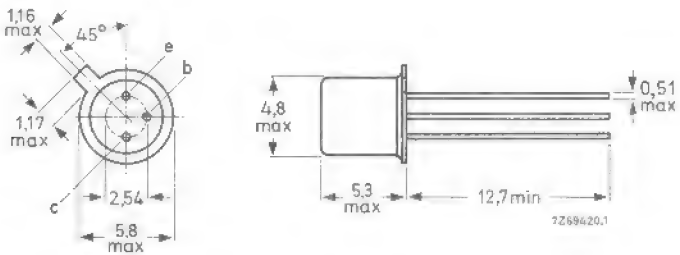
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	180	MHz
Noise figure at R_S = 2 kΩ $-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 1 kHz; B = 200 Hz	F	typ.	2	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BCY78	BCY79	
Voltages					
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V
Currents					
Collector current (d.c.)	$-I_C$	max.	200		mA
Base current (d.c.)	$-I_B$	max.	20		mA
Power dissipation					
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		mW
Temperatures					
Storage temperature	T_{stg}		−65 to 200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,45	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS $T_{amb} = 25\ ^oC$ unless otherwise specified

Conditions	Symbol		BCY78	BCY79	Unit
Collector cut-off currents					
$V_{BE} = 0$; $-V_{CE} = 25$ V	$-I_{CES}$	typ.	2	–	nA
		<	20	–	nA
$V_{BE} = 0$; $-V_{CE} = 35$ V	$-I_{CES}$	typ.	–	2	nA
		<	–	20	nA
$V_{BE} = 0$; $-V_{CE} = 25$ V; $T_{amb} = 150\ ^oC$	$-I_{CES}$	<	10	–	µA
$V_{BE} = 0$; $-V_{CE} = 35$ V; $T_{amb} = 150\ ^oC$	$-I_{CES}$	<	–	10	µA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	100	100	nA
$-V_{EB} = 0,2$ V; $-V_{CE} = -V_{CEOmax}$; $T_{amb} = 100\ ^oC$	$-I_{CEX}$	<	20	20	µA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	20	20	nA
Collector-emitter breakdown voltage					
$V_{BE} = 0$; $-I_C = 10$ µA	$-V_{(BR)CES}$	>	32	45	V
$I_B = 0$; $-I_C = 2$ mA	$-V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0$; $-I_E = 1$ µA	$-V_{(BR)EBO}$	>	5		V
Base-emitter voltage					
$-I_C = 10$ µA ; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	550		mV
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	650		mV
		600 to	750		mV
$-I_C = 10$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	680		mV
$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	750		mV
Saturation voltages					
$-I_C = 10$ mA; $-I_B = 250$ µA	$-V_{CEsat}$	typ.	120		mV
		<	250		mV
	$-V_{BEsat}$	typ.	700		mV
		600 to	850		mV
$-I_C = 100$ mA; $-I_B = 2,5$ mA	$-V_{CEsat}$	typ.	400		mV
		<	800		mV
	$-V_{BEsat}$	typ.	850		mV
		700 to	1200		mV
Transition frequency at f = 35 MHz					
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	180		MHz

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	4,5	pF
		<	7,0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	typ.	11	pF
		<	15	pF
Noise figure at R_S = 2 kΩ				
$-I_C$ = 200 µA; $-V_{CE}$ = 5 V f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	6	dB

			BCY78-VII BCY79-VII	VIII VIII	IX IX	X	
D.C. current gain							
$-I_C$ = 10 µA ; $-V_{CE}$ = 5 V	h_{FE}	>	–	30	40	100	
		typ.	140	200	270	340	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	120	180	250	380	
		typ.	170	250	350	500	
		<	220	310	460	630	
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	80	120	160	240	
		typ.	180	260	360	500	
		<	–	400	630	1000	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	40	45	60	60	
h-parameters at f = 1 kHz							
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V							
Input impedance	h_{ie}	typ.	2,7	3,6	4,5	7,5	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1,5	2	2	3	10^{-4}
Small-signal current gain	h_{fe}	>	125	175	250	350	
		typ.	200	260	330	520	
		<	250	350	500	700	
Output admittance	h_{oe}	typ.	18	24	30	50	µA/V
		<	30	50	60	100	µA/V

CHARACTERISTICS (continued)

Switching times

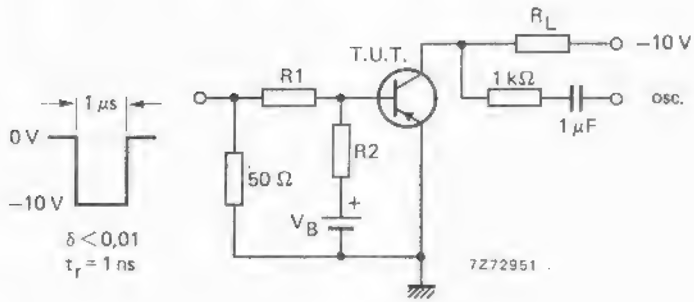
$-I_{Con}$ = 10 mA; $-I_{Bon} = I_{Boff}$ = 1 mA
R1 = R2 = 5 kΩ; R_L = 990 Ω
V_B = 3,6 V

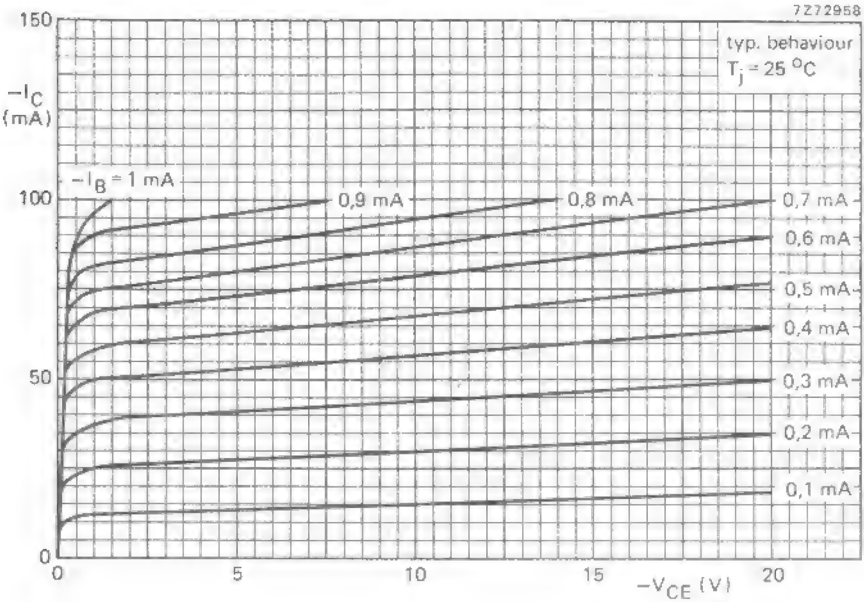
delay time	t_d	typ.	35	ns
rise time	t_r	typ.	50	ns
turn-on time ($t_d + t_r$)	t_{on}	typ.	85	ns
		<	150	ns
storage time	t_s	typ.	400	ns
fall time	t_f	typ.	80	ns
turn-off time ($t_s + t_f$)	t_{off}	typ.	480	ns
		<	800	ns

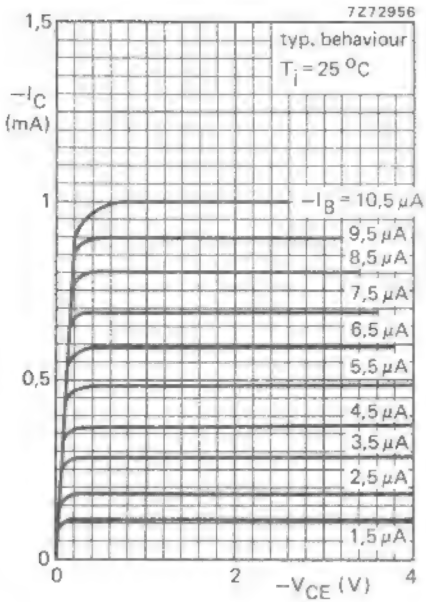
$-I_{Con}$ = 100 mA; $-I_{Bon} = I_{Boff}$ = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_B = 5 V

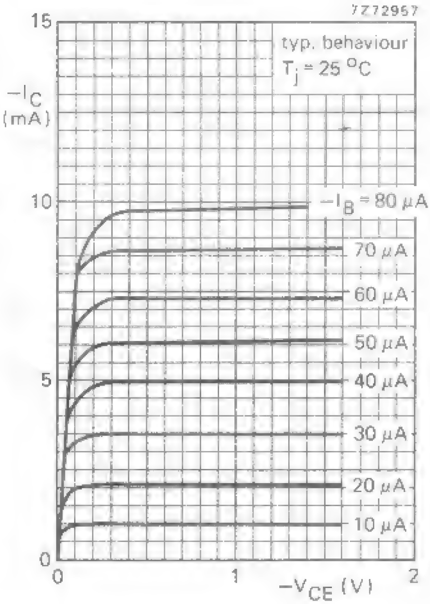
delay time	t_d	typ.	5	ns
rise time	t_r	typ.	50	ns
turn-on time ($t_d + t_r$)	t_{on}	typ.	55	ns
		<	150	ns
storage time	t_s	typ.	250	ns
fall time	t_f	typ.	200	ns
turn-off time ($t_s + t_f$)	t_{off}	typ.	450	ns
		<	800	ns

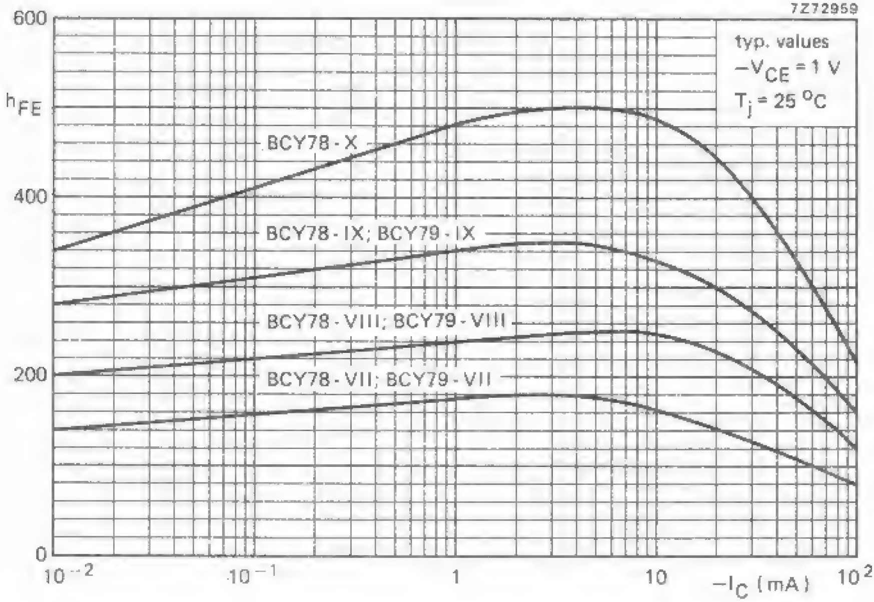
Test circuit:

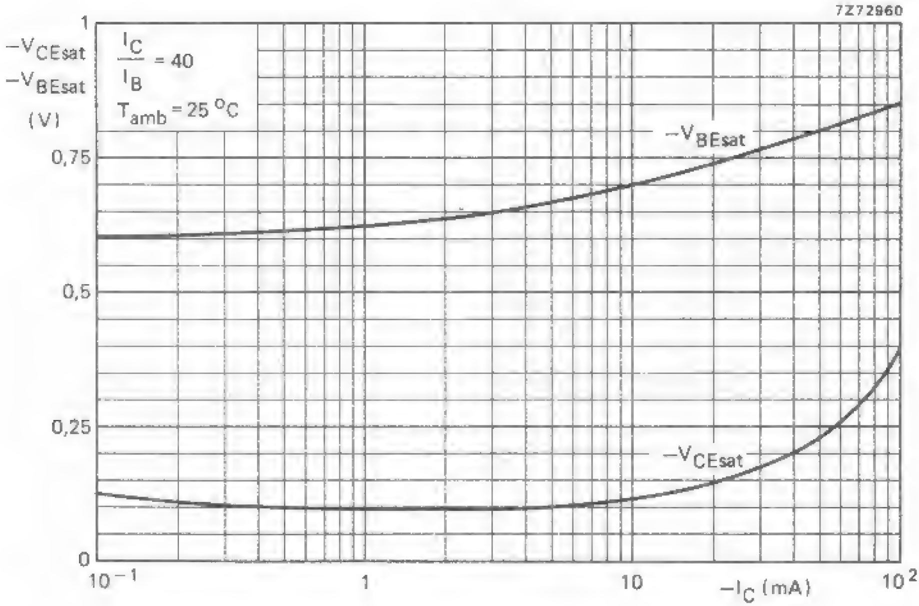


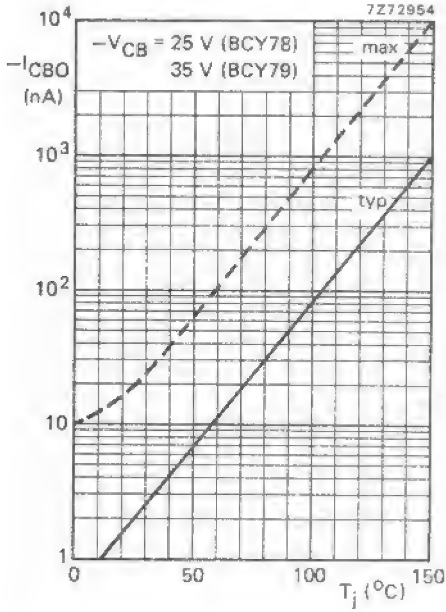

7Z72958
typ. behaviour
$T_j = 25\ ^oC$
$-I_C$ (mA)
150
100
50
0
$-I_B = 1$ mA
0,9 mA
0,8 mA
0,7 mA
0,6 mA
0,5 mA
0,4 mA
0,3 mA
0,2 mA
0,1 mA
0
5
10
15
20
$-V_{CE}$ (V)

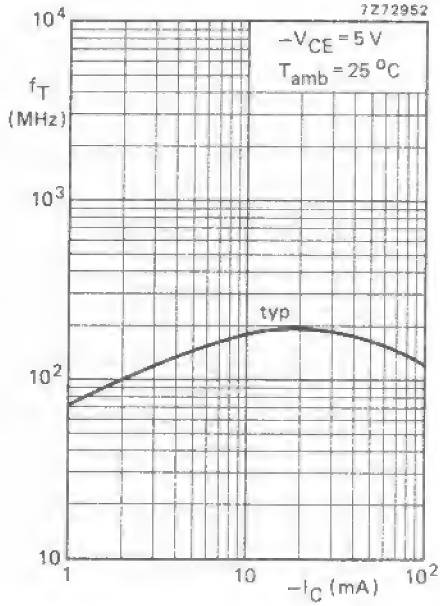

7Z72956
typ. behaviour
$T_j = 25\ ^oC$
$-I_C$ (mA)
1,5
1
0,5
0
$-I_B = 10,5\ \mu A$
9,5 μA
8,5 μA
7,5 μA
6,5 μA
5,5 μA
4,5 μA
3,5 μA
2,5 μA
1,5 μA
0
2
4
$-V_{CE}$ (V)

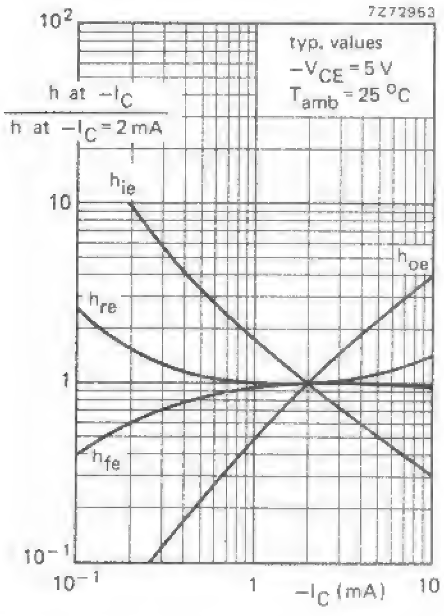

7Z72957
typ. behaviour
$T_j = 25\ ^oC$
$-I_C$ (mA)
15
10
5
0
$-I_B = 80\ \mu A$
70 μA
60 μA
50 μA
40 μA
30 μA
20 μA
10 μA
0
1
2
$-V_{CE}$ (V)

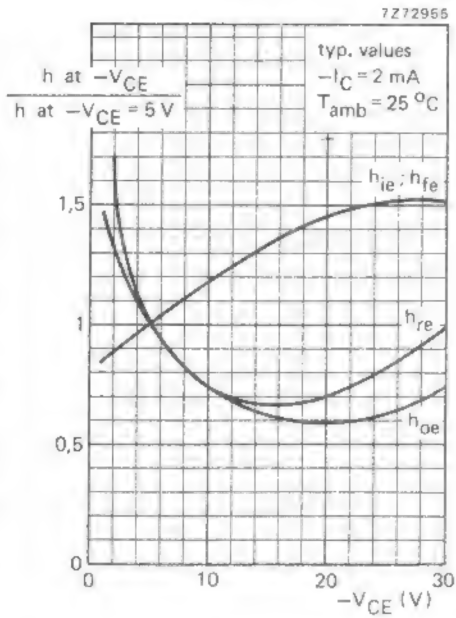

7Z72959
typ. values
$-V_{CE} = 1$ V
$T_j = 25$ °C
h_{FE}
600
400
200
0
BCY78 - X
BCY78 - IX; BCY79 - IX
BCY78 - VIII; BCY79 - VIII
BCY78 - VII; BCY79 - VII
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72960
$-V_{CEsat}$
$-V_{BEsat}$
(V)
1
0,75
0,5
0,25
0
$\frac{I_C}{I_B} = 40$
$T_{amb} = 25$ °C
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72954
$-I_{CBO}$ (nA)
$-V_{CB}$ = 25 V (BCY78)
35 V (BCY79)
max
typ
T_j (°C)


7Z72952
f_T (MHz)
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
typ
$-I_C$ (mA)


7Z72953
h at $-I_C$ / h at $-I_C$ = 2 mA
typ. values
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
h_{ie}
h_{oe}
h_{re}
h_{fe}
$-I_C$ (mA)


7Z72966
h at $-V_{CE}$ / h at $-V_{CE}$ = 5 V
typ. values
$-I_C$ = 2 mA
T_{amb} = 25 °C
h_{ie} ; h_{fe}
h_{re}
h_{oe}
$-V_{CE}$ (V)

N-P-N SILICON PLANAR DUAL TRANSISTORS FOR DIFFERENTIAL AMPLIFIERS

Matched dual n-p-n transistors in a TO-71 metal envelope with all leads insulated from the case. They are primarily intended for differential amplifier applications in general industrial service; e.g. instrumentation and control.

Products are divided into three types according to their matching accuracy.
The BCY87 and BCY88 are intended for applications in pre-stages of differential amplifiers where low offset, drift and noise are of prime importance. The BCY89 is for second stages, long-tailed pairs and more general purposes.

QUICK REFERENCE DATA

Ratings

Collector-base voltage (open emitter)	V_{CBO}	max	45	V
Collector-emitter voltage (open base)	V_{CEO}	max	40	V
Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max	150	mW
Junction temperature	T_j	max	175	^{o}C

Characteristics of the complete device with collector-base voltage of 10 V and sum of emitter currents from 10 to 100 μA.

			BCY87	BCY88	BCY89	
Ratio of collector currents at $V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}		0,9–1,11	0,8–1,25	0,67–1,5	
Base current difference at $V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B}-I_{2B}\rvert$	<	25	80	300	nA
Equivalent differential voltage change with temperature *	$\left\lvert\frac{\Delta V}{\Delta T}\right\rvert$	<	3	6	10	$\mu V/^{o}C$
Equivalent differential current change with temperature *	$\left\lvert\frac{\Delta I}{\Delta T}\right\rvert$	<	0,5	2	10	$nA/^{o}C$

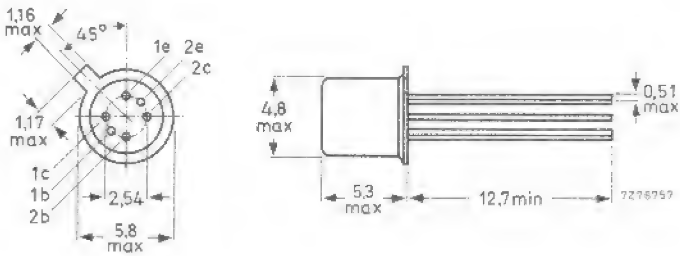
MECHANICAL DATA

Dimensions in mm

TO-71

All leads insulated from the case

Accessories:
56263 (cooling fin).



* $T_{amb} = -20\ ^{o}C$ to $+90\ ^{o}C$.

RATINGS see page 7

CHARACTERISTICS of the individual transistors

T_{amb} = 25 ^{o}C unless otherwise specified

			BCY87	BCY88	BCY89	
Collector cut-off currents						
I_E = 0; V_{CB} = 20 V; T_{amb} = 90 ^{o}C	I_{CBO}	<	5	20	–	nA
I_E = 0; V_{CB} = 20 V	I_{CBO}	<	–	–	10	nA
D.C. current gain						
I_C = 5 μA; V_{CB} = 10 V	h_{FE}	>	80	–	–	
I_C = 50 μA; V_{CB} = 10 V	h_{FE}	>	100	100	100	
		<	450	450	450	
I_C = 500 μA; V_{CB} = 10 V	h_{FE}	>	–	120	–	
		<	–	600	–	
I_C = 10 mA; V_{CB} = 10 V	h_{FE}	>	–	–	100	
		<	–	–	600	
Transition frequency						
$-I_E$ = 50 μA; V_{CB} = 10 V	f_T	>	10	10	10	MHz
$-I_E$ = 500 μA; V_{CB} = 10 V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	3.5	3.5	3.5	pF
Noise figures						
I_C = 50 μA; V_{CE} = 5 V; R_S = 10 kΩ Bandwidth 10 Hz to 15 kHz	F	<	3	4	4	dB
1 kHz spot noise figure I_C = 50 μA; V_{CE} = 5 V; R_S = opt. Bandwidth = 200 Hz	F	<	4	5	5	dB

CHARACTERISTICS of the complete device.

These characteristics are valid under the following conditions:

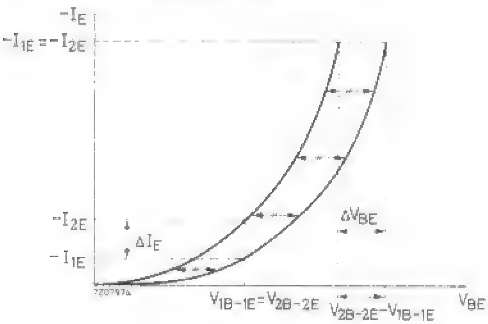
a. Collector-base voltage of both transistors not exceeding 10 V ($V_{1C-1B} = V_{2C-2B} \leq 10$ V)

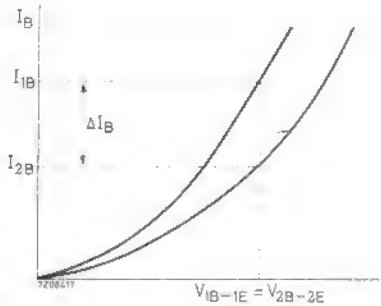
b. Sum of the emitter currents from 10 to 100 μA
  $-(I_{1E} + I_{2E}) = 10$ to 100 μA

MATCHING CHARACTERISTICS

		BCY87	BCY88	BCY89	
Ratio of collector currents					
$V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}	0.9-1.11	0.8-1.25	0.67-1.5	
Difference between base-emitter voltages					
$I_{1C} = I_{2C}$	$\lvert V_{1B-1E} - V_{2B-2E} \rvert$	< 3	6	10	mV
Difference between base currents					
$V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B} - I_{2B} \rvert$	< 25	80	300	nA
D.C. current gain ratio					
$I_{1C} = I_{2C}$	h_{1FE}/h_{2FE}	0.9-1.11	0.8-1.25	–	

Illustration of matching characteristics:





$$\frac{I_{2E}}{I_{1E}} = \exp. \frac{q}{KT} \cdot \Delta V_{BE}$$

$\frac{I_{2E}}{I_{1E}}$ measured at $\Delta V_{BE} = 0$

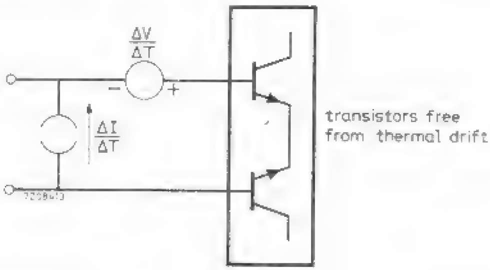
ΔV_{BE} measured at $\frac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

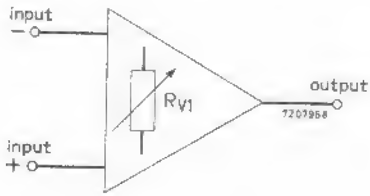
In the equivalent circuit the transistors are considered to be drift free.
All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

It should be noted that the differential current change given is only valid when the source resistances are almost equal; the differential voltage change only when the base-emitter voltages are almost equal.



Block symbol of test amplifier

The test amplifier, used in the tests on page 5, is described on pages 6 and 7. It is represented by the following amplifier symbol:



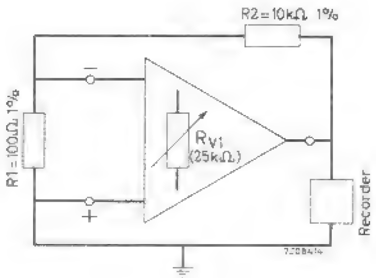
CHARACTERISTICS of the complete device (continued)

Equivalent differential voltage change with temperature

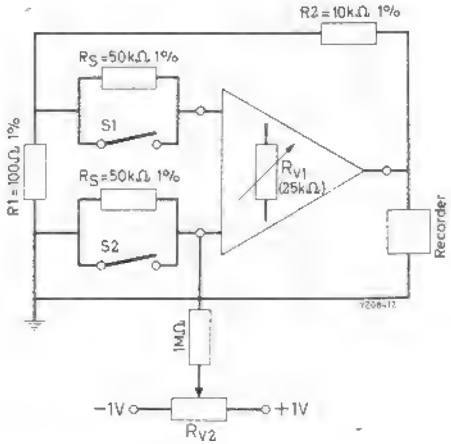
			BCY87	BCY88	BCY89	
Tamb = −20 to +90 °C	$\left\lvert\frac{\Delta V}{\Delta T}\right\rvert$	typ.	1	2	4	μV/°C
		<	3	6	10	μV/°C
Equivalent differential current change with temperature						
Tamb = −20 to +90 °C	$\left\lvert\frac{\Delta I}{\Delta T}\right\rvert$	<	0.5	2	10	nA/°C

Test methods

$\boxed{\frac{\Delta V}{\Delta T}}$



$\boxed{\frac{\Delta I}{\Delta T}}$



NOTE

To prevent contact potentials, connections should be soldered.

Amplification factor determined by feedback circuit: $\frac{R2}{R1} = 100$

Output voltage against time is recorded.

The temperature of the amplifier is adjusted to T_1 between −20 and +90 °C. When it has stabilized, the output voltage is brought to zero ($|V_{T1}| < 1$ mV)[1]). The amplifier temperature is then adjusted to T_2 between −20 and +90 °C. When it has stabilized the output voltage can be read off.

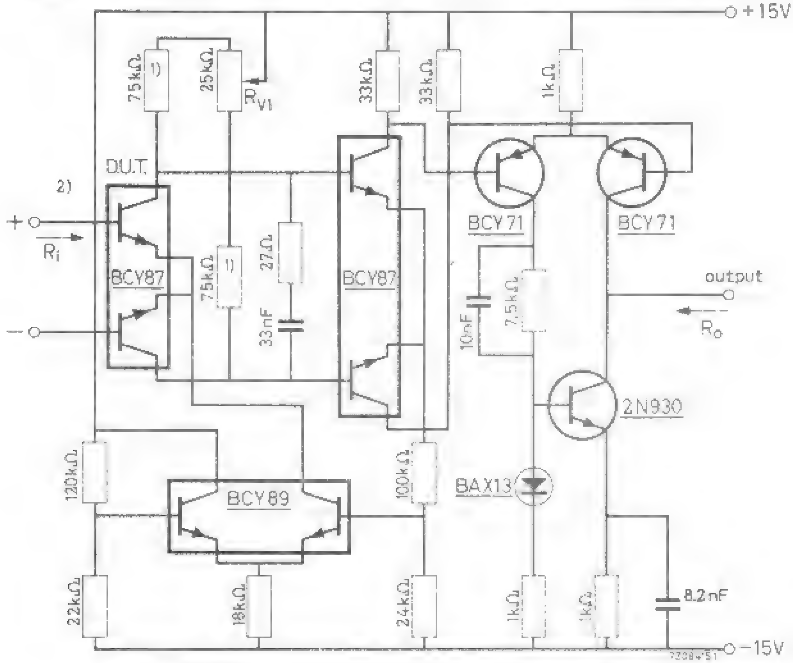
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

[1]) For $\frac{\Delta V}{\Delta T}$: adjusted by R_{V1}

For $\frac{\Delta I}{\Delta T}$: first by R_{V1} with S1 and S2 closed, then by R_{V2} with the switches open.

Differential test-amplifier

The test amplifier (including feedback resistors, source-resistors and biasing-resistors) should be mounted in a small box to ensure a uniform temperature throughout.

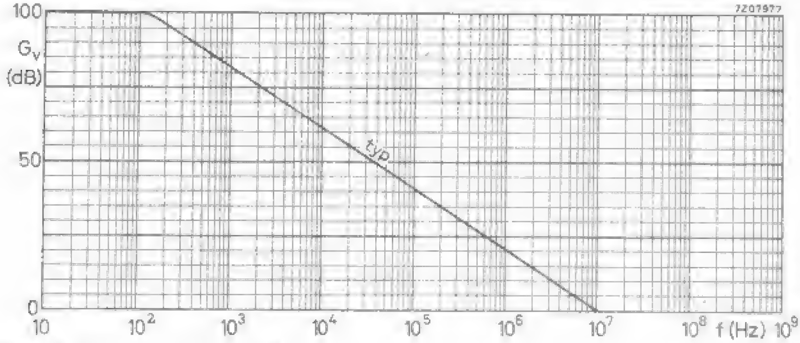


1) Relative temperature coefficient $< 10^{-5}/^{o}C$

2) The device at the input is the device under test

Performance of the test amplifier

Open loop voltage gain (Z_L = 10 kΩ)	G_V	typ.	10^5	
Frequency at which G_V = 1	f_1	typ.	10	MHz
Max. common mode input voltage range			±10	V
Max. output current			±2.5	mA
Max. output voltage			±10	V
Input resistance	R_i		100	kΩ
Output resistance	R_o	typ.	20	kΩ
Common mode rejection ratio			10^5	



RATINGS (Limiting values) [1])

Voltages (each transistor)

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents (each transistor)

Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	max.	175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	1	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant. The BF198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

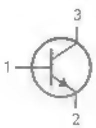
QUICK REFERENCE DATA

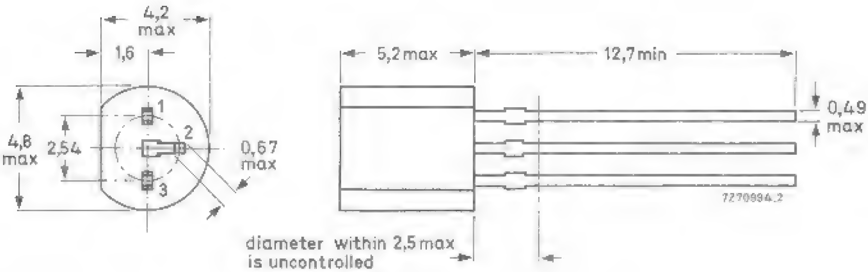
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	200	fF
Max. unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d. c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}	−65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Base current at about 50 dB gain control				
I_C = 6 mA; V_{CE} = 2 V	I_B	<	270	μA
I_C = 15 mA; V_{CE} = 5 V	I_B	<	1.5	mA
Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	60	μA
		<	150	μA
Base-emitter voltage 1)				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	760	mV
		<	850	mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	200	fF
Transition frequency at f = 100 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Noise figure				
I_C = 4 mA; V_{CE} = 10 V G_S = 10 mA/V; f = 35 MHz; B_S = 0	F	typ.	3	dB

y parameters (common emitter)

I_C = 4 mA; V_{CE} = 10 V

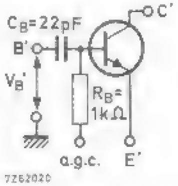
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	3.2	4.8	mA/V
Input capacitance	C_{ie}	typ.	37	35	pF
Feedback admittance	$\|y_{re}\|$	typ.	47	60	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\|y_{fe}\|$	typ.	105	100	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	μA/V
Output capacitance	C_{oe}	typ.	1.3	1.3	pF
Maximum unilateralized power gain					
G_{UM} (in dB) = $10 \log \frac{\|y_{fe}\|^2}{4 g_{ie} g_{oe}}$					
I_C = 4 mA; V_{CE} = 10 V	G_{UM}	typ.	42	39	dB

1) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

Equivalent gain control transistor

To ensure an almost constant input admittance and an output conductance that varies little with gain control, we recommend that where a BF198 is used in a gain controlled i.f. stage, a series base capacitor of 22 pF and a bias resistor of 1 kΩ be used.

Fig. 2



The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only be expressed in terms of power).

The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on Figs. 3 to 6.

a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on Figs. 5 and 6.

Graphs of the y-parameters are on Figs. 13 to 28.

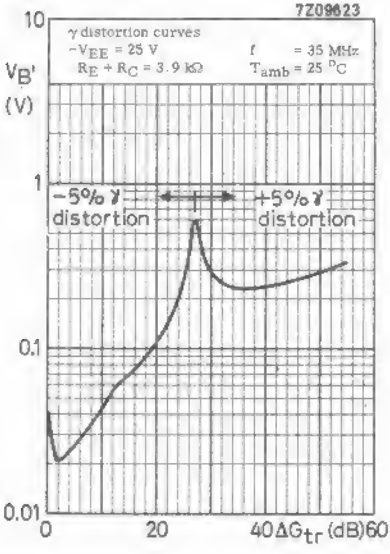


Fig. 3

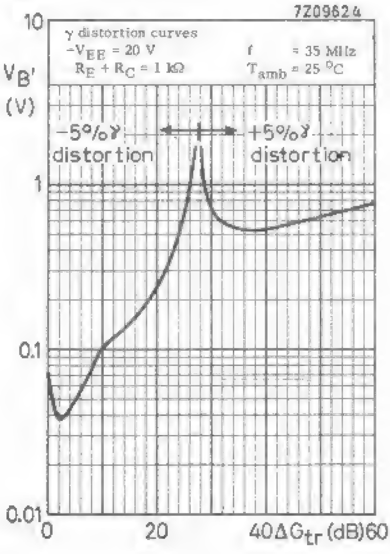


Fig. 4

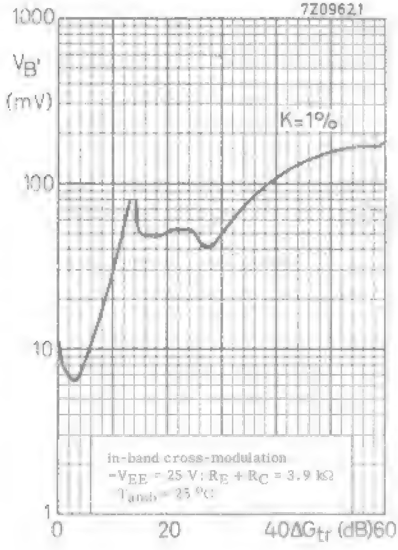

7Z09621
1000
100
10
1
$V_{B'}$
(mV)
K=1%
in-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

Fig. 5

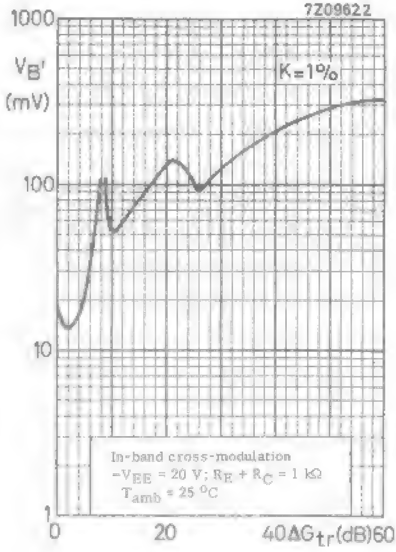

7Z09622
1000
100
10
1
$V_{B'}$
(mV)
K=1%
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

Fig. 6

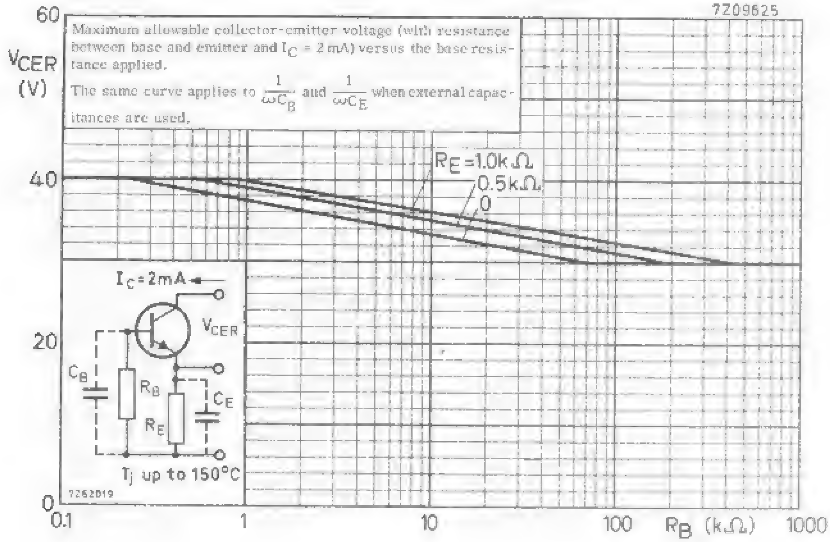

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CER} (V)
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 150°C
7Z62019
R_B (kΩ)
60
40
20
0
0.1
1
10
100
1000

Fig. 7

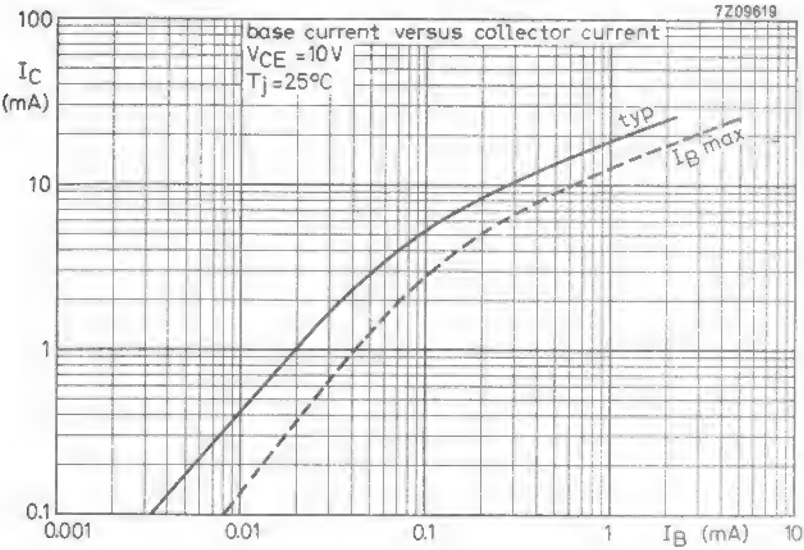

7Z09619
base current versus collector current
V_{CE} = 10 V
T_j = 25°C
I_C (mA)
typ
I_B max
I_B (mA)
100
10
1
0.1
0.001
0.01
0.1
1
10

Fig. 8

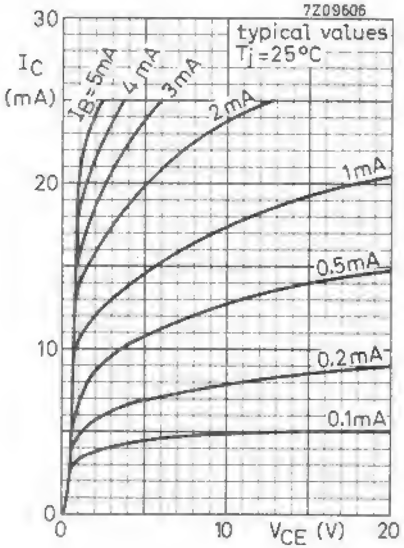


Fig. 9

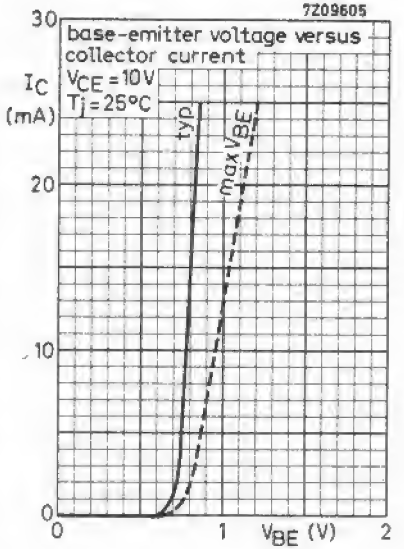


Fig. 10

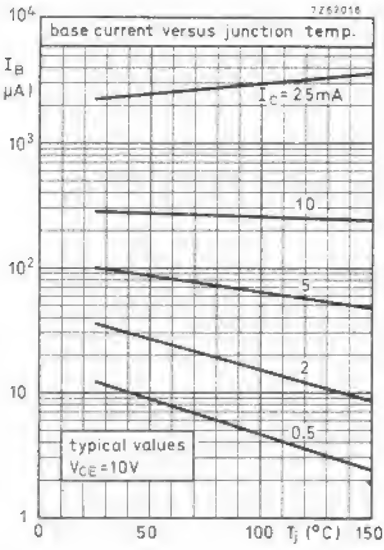


Fig. 11

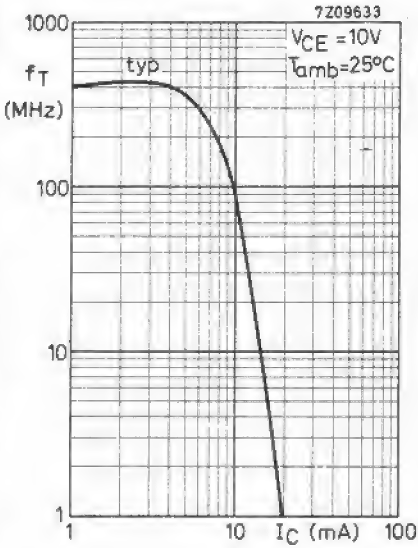


Fig. 12

Voltage control: $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz

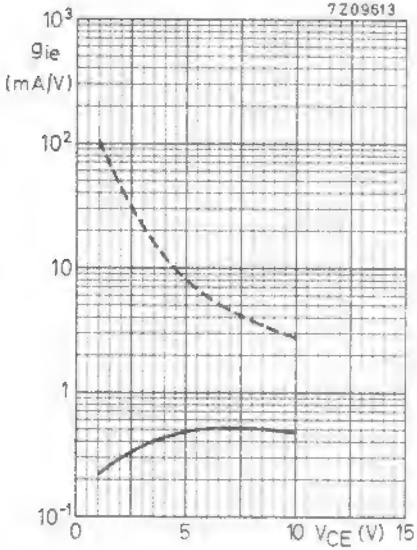


Fig. 13

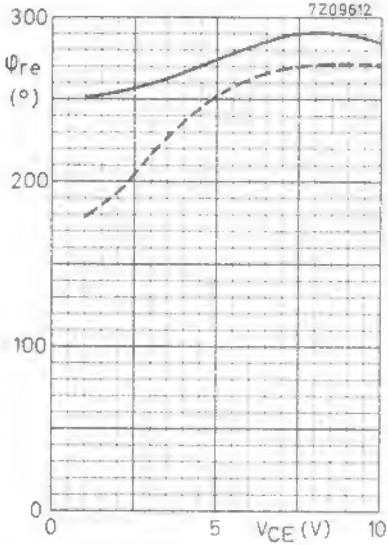


Fig. 14

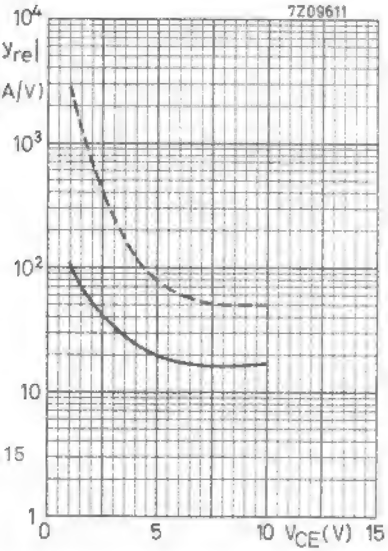


Fig. 15

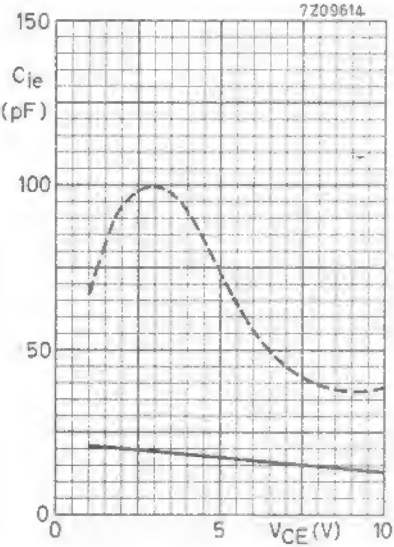


Fig. 16

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

Voltage control; $-V_{EE} = 25$ V; $R_E + R_C = 3.9$ kΩ; f = 35 MHz

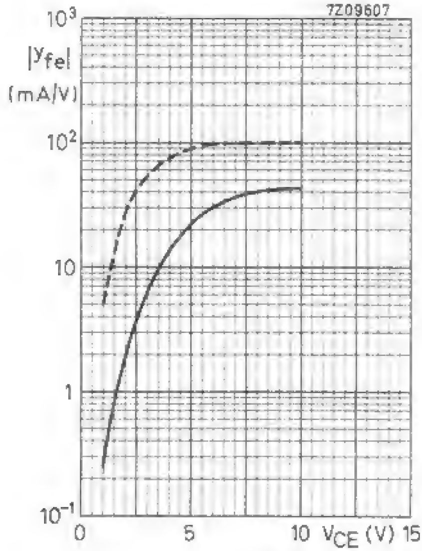


Fig. 17

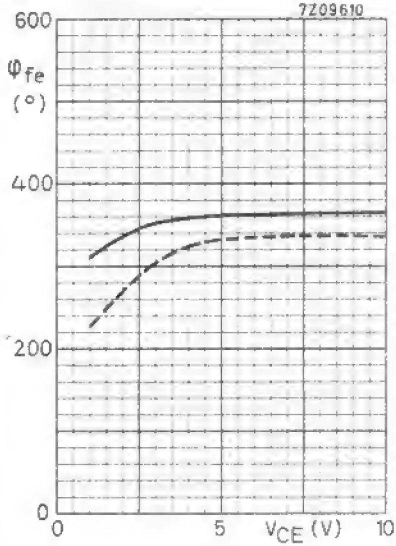


Fig. 18

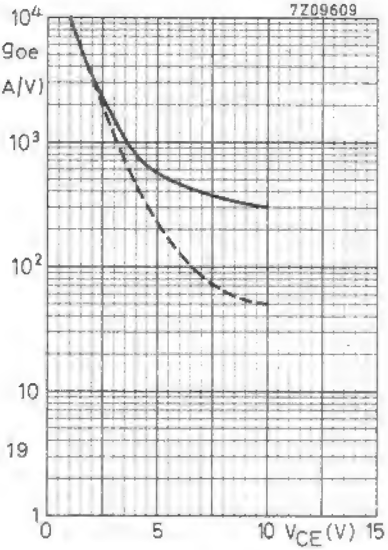


Fig. 19

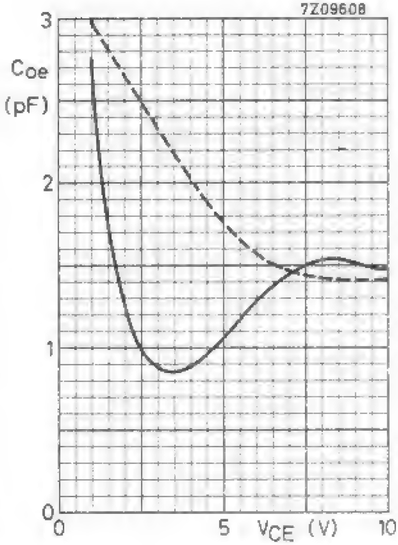


Fig. 20

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz

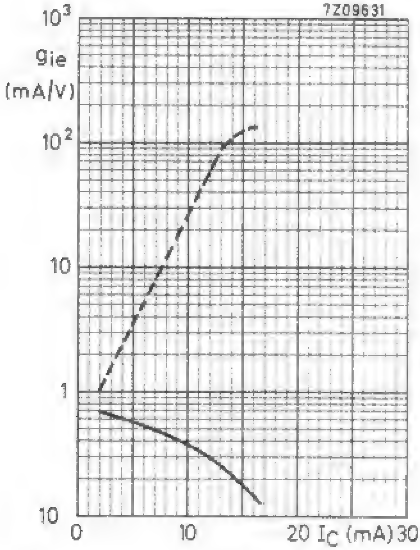


Fig. 21

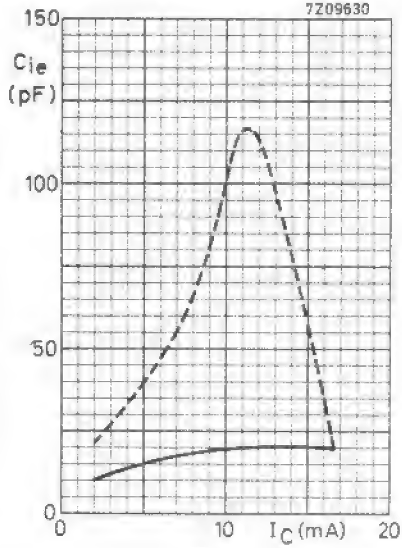


Fig. 22

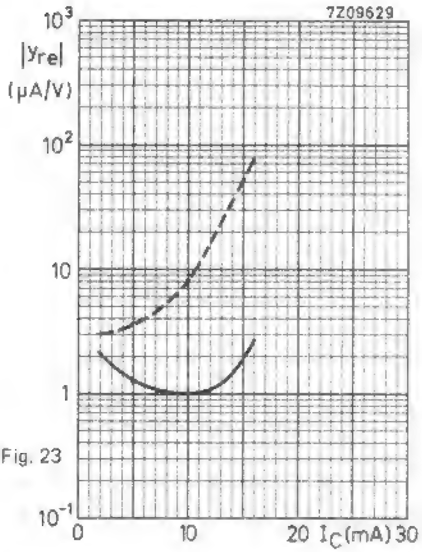


Fig. 23

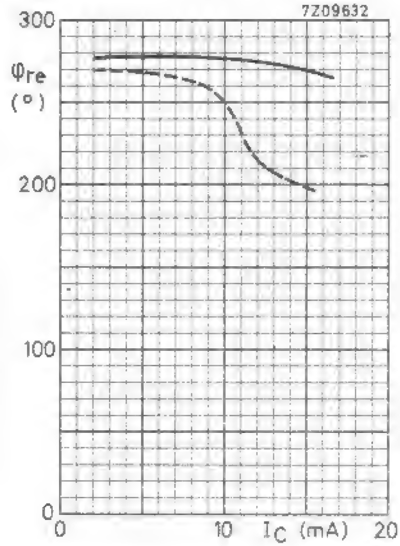


Fig. 24

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz

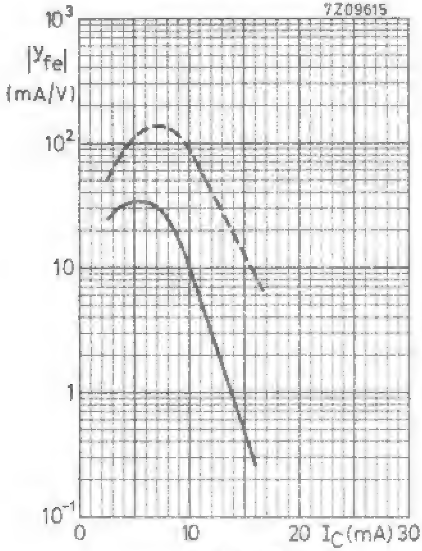


Fig. 25

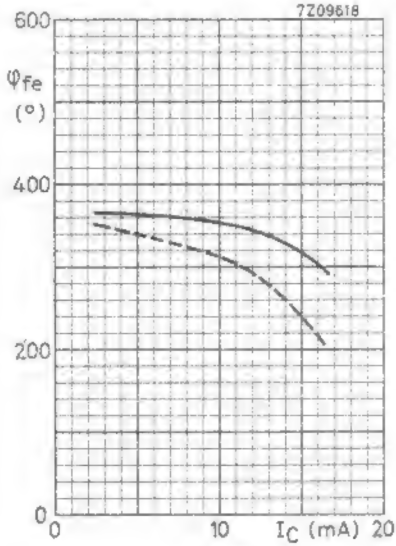


Fig. 26

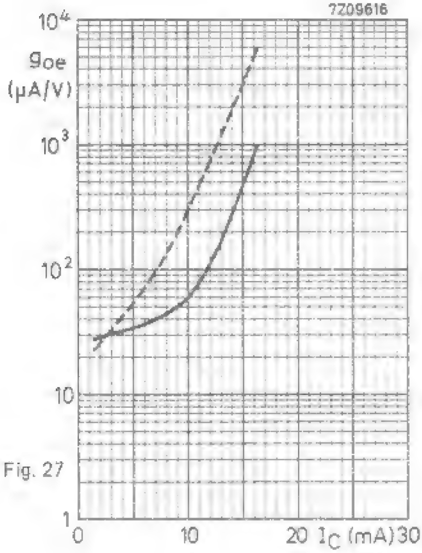


Fig. 27

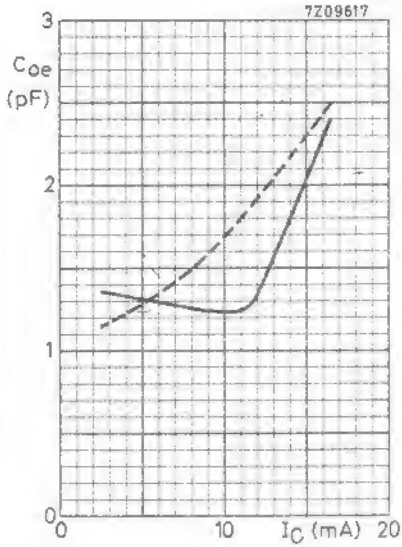


Fig. 28

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

First stage of an i.f. amplifier

Basic circuit with voltage gain control: $R_E + R_C = 3.9\ k\Omega$; $-V_{EE} = 25\ V$

current gain control: $R_E + R_C = 1\ k\Omega$; $-V_{EE} = 20\ V$

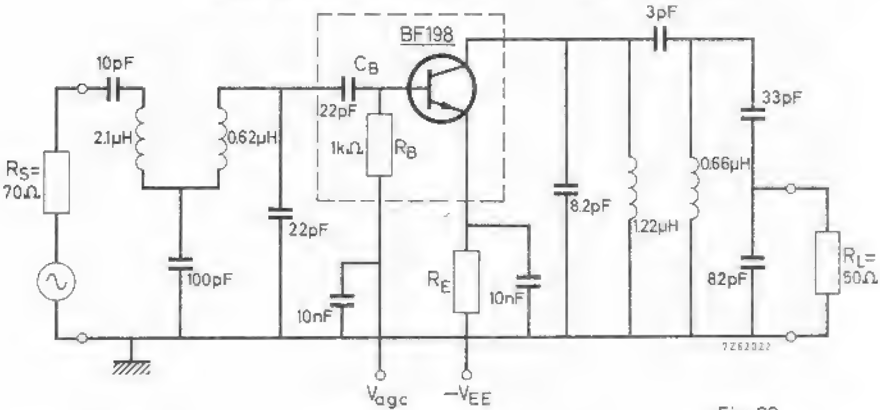


Fig. 29

Transducer gain

$$G_{tr}\ (\text{in dB}) = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

$f = 36.4\ MHz$; $I_C = 4\ mA$; $R_E + R_C = 3.9\ k\Omega$; $-V_{EE} = 25\ V$	G_{tr}	typ.	25.5	dB
Gain control range (see also upper graphs next page)	ΔG_{tr}	typ.	60	dB

Voltage gain control

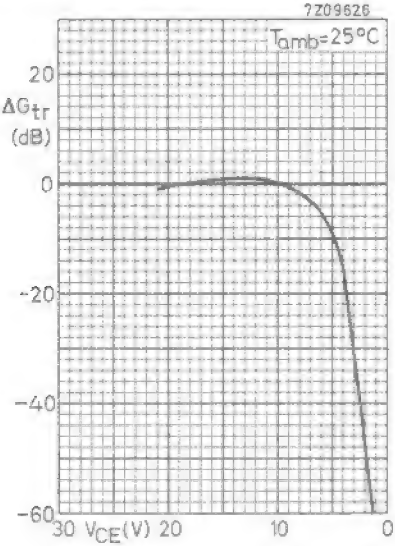


Fig. 30

Current gain control

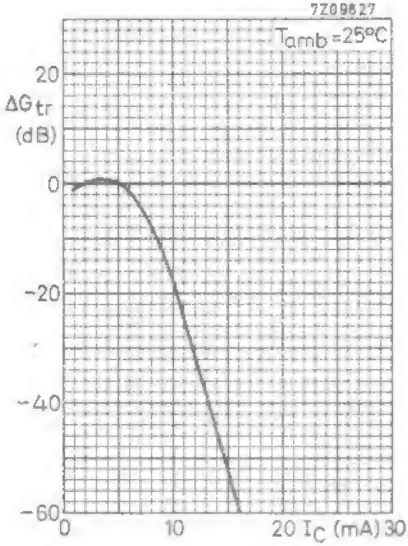


Fig. 31

Curves of constant gain reduction

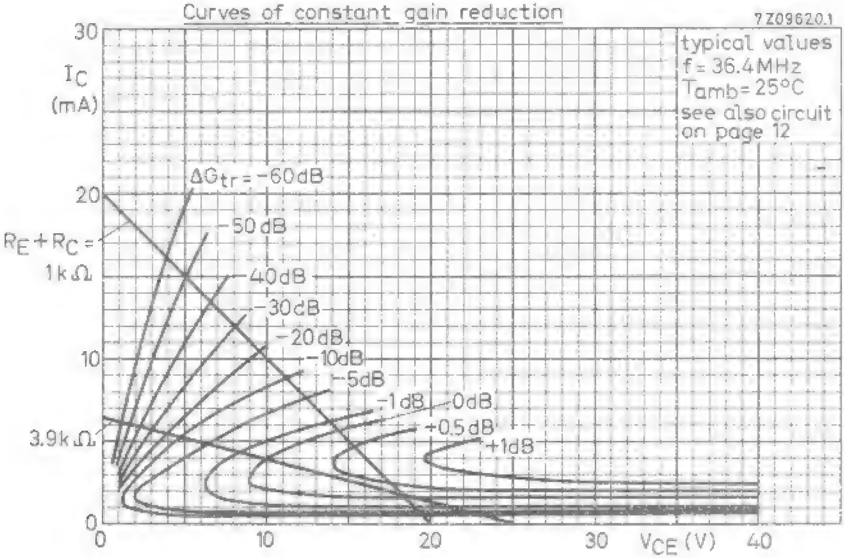


Fig. 32

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope.

The BF199 has a very low feedback capacitance and is intended for use in the output stage of a vision i.f. amplifier.

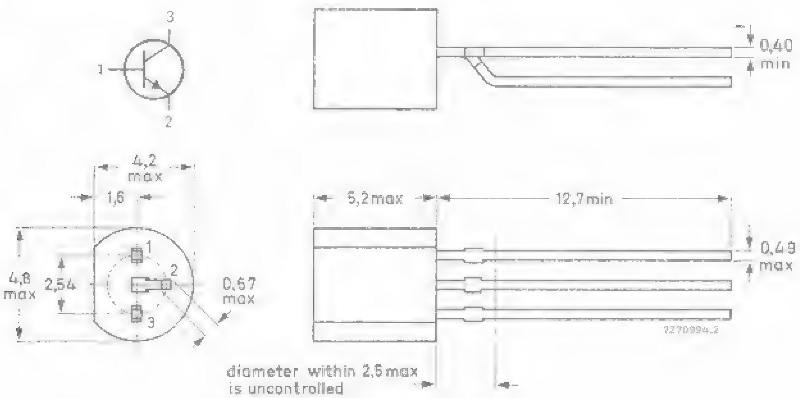
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	340	fF
Maximum unilateral power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	44,4	dB
Video detector output voltage	V_O	typ.	7,7	V

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d. c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

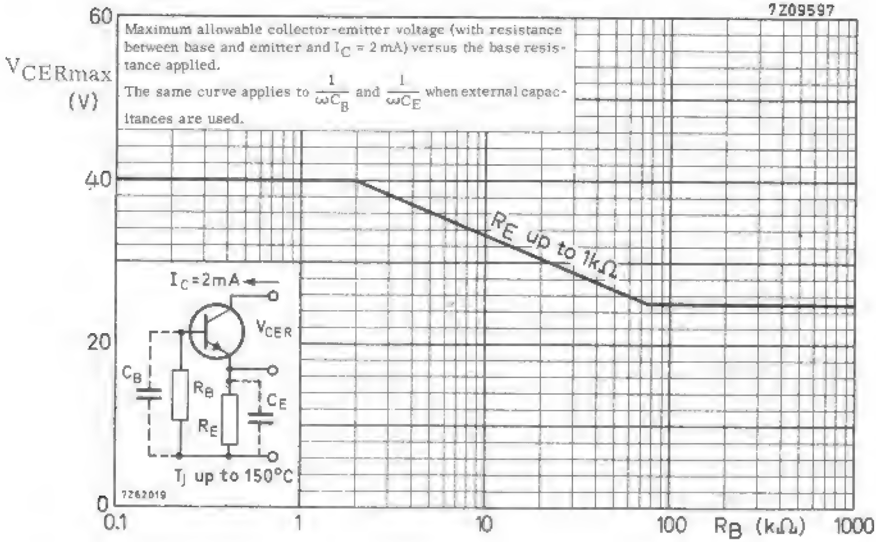
Base current $I_C = 7$ mA; $V_{CE} = 10$ V	I_B	typ. <	60 μA 185 μA
Base-emitter voltage * $I_C = 7$ mA; $V_{CE} = 10$ V	V_{BE}	typ. <	775 mV 925 mV
Transition frequency at f = 100 MHz $I_C = 5$ mA; $V_{CE} = 10$ V	f_T	typ.	550 MHz
Feedback capacitance at f = 10,7 MHz $I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	340 fF
y-parameters (common emitter) $I_C = 7$ mA; $V_{CE} = 10$ V; f = 35 MHz			
input conductance	g_{ie}	typ.	5,5 mA/V
input capacitance	C_{ie}	typ.	55 pF
feedback admittance	$\vert y_{re}\vert$	typ.	75 μA/V
phase angle of feedback admittance	φ_{re}	typ.	268°
transfer admittance	$\vert y_{fe}\vert$	typ.	220 mA/V
phase angle of transfer admittance	φ_{fe}	typ.	338°
output conductance	g_{oe}	typ.	80 μA/V
output capacitance	C_{oe}	typ.	2,0 pF

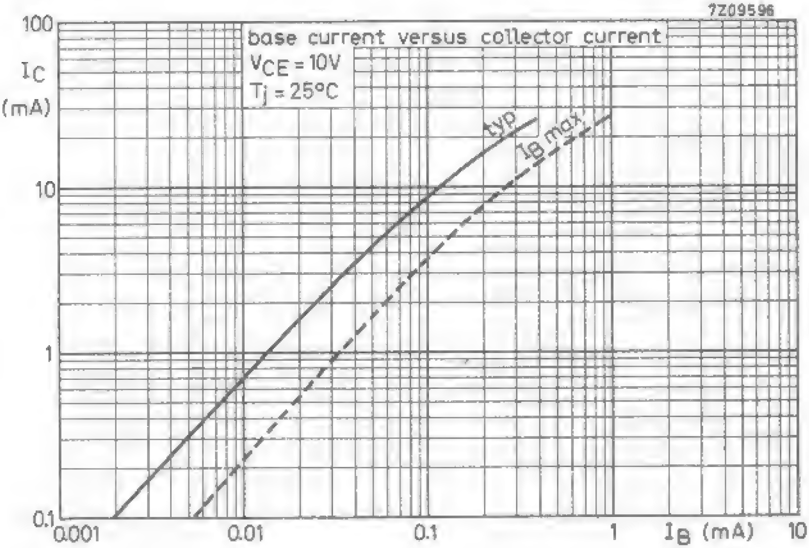
Maximum unilateral power gain

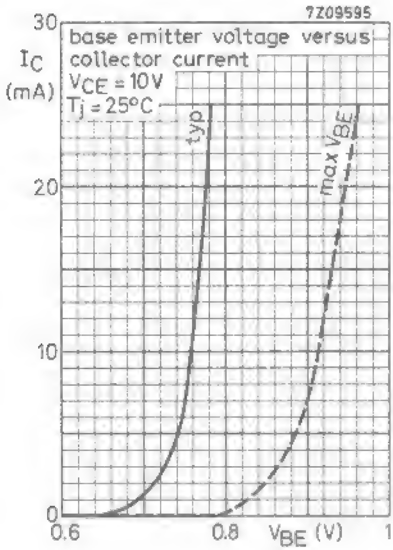
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4\, g_{ie}\, g_{oe}}$$

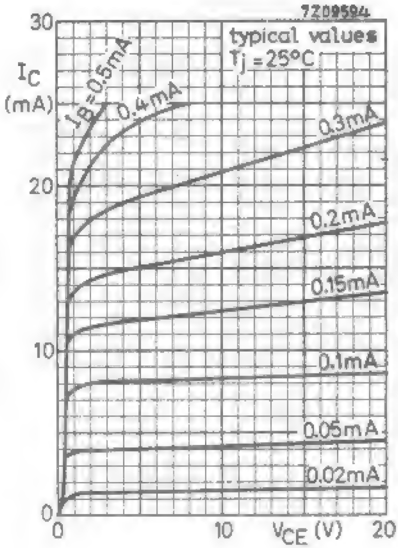
$I_C = 7$ mA; $V_{CE} = 10$ V	G_{UM}	typ.	44,4 dB

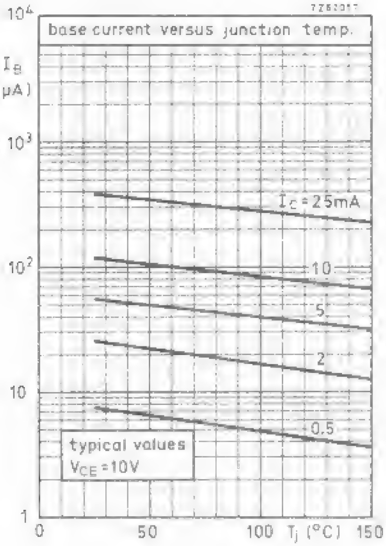
* V_{BE} decreases by about 1,7 mV/K with increasing temperature.

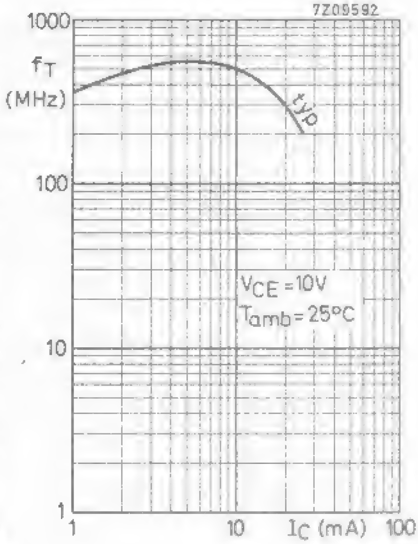

7Z09597
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CERmax} (V)
60
40
20
0
R_E up to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
C_E
R_E
T_j up to 150°C
7Z62019
0.1
1
10
100
R_B (kΩ)
1000


7Z09596
base current versus collector current
$V_{CE} = 10V$
$T_j = 25°C$
I_C
(mA)
typ
I_B max
100
10
1
0.1
0.001
0.01
0.1
1
I_B (mA)
10


7Z09595
base emitter voltage versus collector current
$V_{CE} = 10V$
$T_j = 25°C$
I_C
(mA)
typ
max V_{BE}
30
20
10
0
0.6
0.8
V_{BE} (V)
1

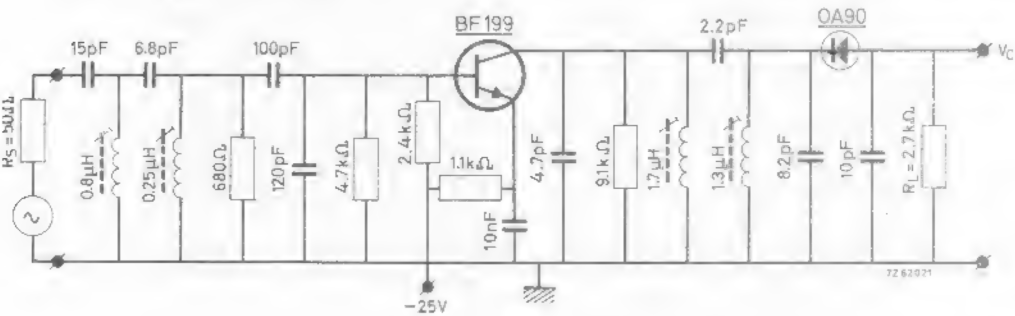

7Z09594
typical values
$T_j = 25°C$
I_C
(mA)
I_B=0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA
30
20
10
0
10
V_{CE} (V)
20





APPLICATION INFORMATION

Output stage of television video i.f. amplifier with the BF199 transistor, followed by a video detector circuit.



APPLICATION INFORMATION (continued)

Video detector output voltage at f = 38.9 MHz [1]

I_C = 7.2 mA; V_{CE} = 16.6 V	V_O	>	6	V
		typ.	7.7	V

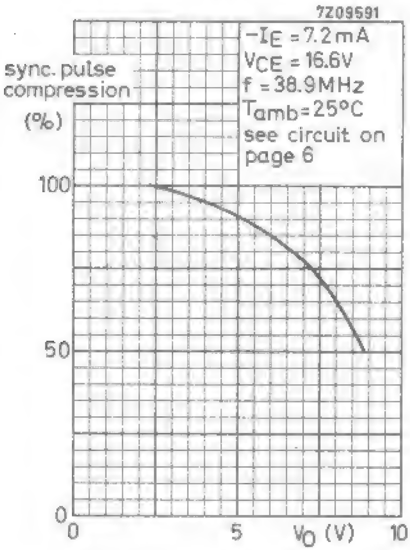
Transducer gain at f = 36.4 MHz

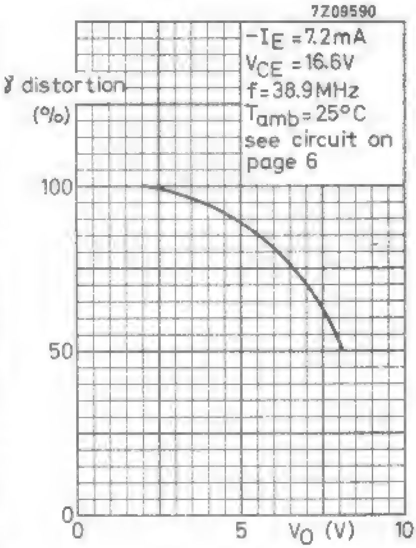
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

I_C = 7.2 mA; V_{CE} = 16.6 V	G_{tr}	typ.	25.5	dB

Tuning frequency for all tuned circuits is 37 MHz

[1]) The output voltage V_O is difined as the voltage across the 2.7 kΩ detector load R_L for 30% synchronisation pulse compression.





H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic envelope, recommended for a.m. mixers and i.f. amplifiers in a.m./f.m. receivers.

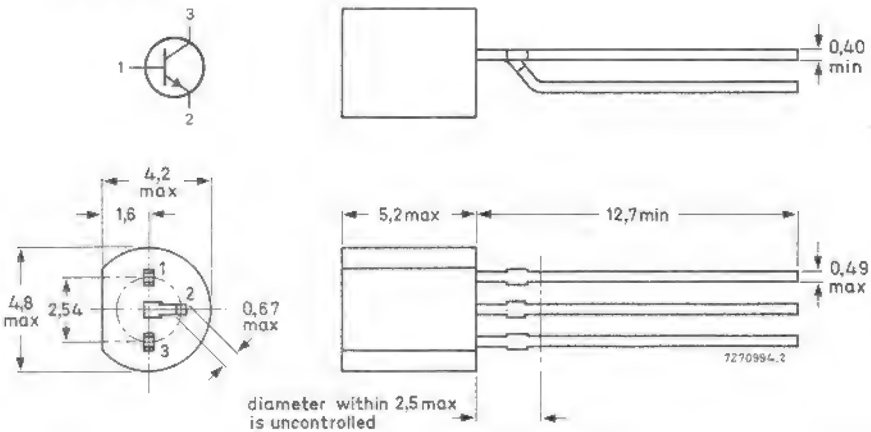
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.		40	V
Collector-emitter voltage (open base)	V_{CEO}	max.		40	V
Collector current (d.c.)	I_C	max.		25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.		250	mW
Junction temperature	T_j	max.		150	°C
			BF240	BF241	
Base current I_C = 1 mA; V_{CE} = 10 V	I_B		4,5-15	8-28	μA
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	380	350	MHz
Feedback capacitance at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	<		0,34	pF
Noise figure I_C = 1 mA; V_{CE} = 10 V; R_S = 200 Ω; f = 0,2 MHz	F	<		3,5	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40 V
Emitter-base voltage (open collector)	V_{EBO}	max.	4 V
Collector current (d.c.)	I_C	max.	25 mA
→ Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250 mW
→ Storage temperature	T_{stg}		−65 to + 150 °C
→ Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

→ From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current $I_E = 0$; V_{CB} = 20 V	I_{CBO}	<	100 nA
Base-emitter voltage I_C = 1 mA; V_{CE} = 10 V	V_{BE}	typ. 	700 mV 650 to 740 mV

			BF240	BF241	
Base current I_C = 1 mA; V_{CE} = 10 V	I_B		4,5–15	8–28	μA
Transition frequency at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	380	350	MHz
Feedback capacitance at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ. <	0,27 0,34	0,27 0,34	pF pF
Noise figure I_C = 1 mA; V_{CE} = 10 V R_S = 200 Ω; f = 0,2 MHz	F	typ. <	1,5 3,5	2,0 3,5	dB dB

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

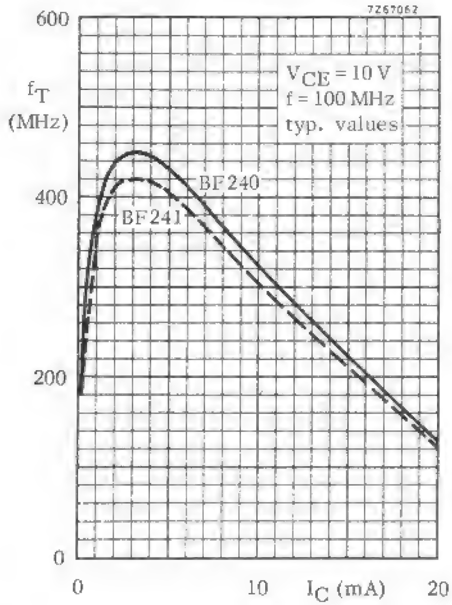
y parameters (common emitter) Lead length = 3 mm

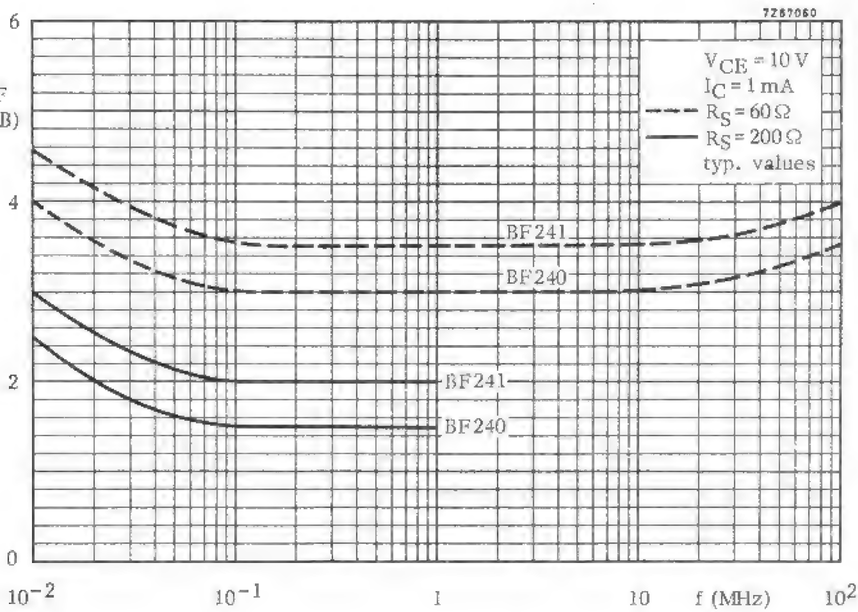
$I_C = 1$ mA; $V_{CE} = 10$ V

			BF240		BF241		
	f	=	0, 45	10, 7	0, 45	10, 7	MHz
Input conductance	g_{ie}	typ.	0, 2	0, 3	0, 4	0, 5	mA/V
Input capacitance	C_{ie}	typ.	17	14	23	19	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	<	8, 3	10, 5	8, 3	10, 5	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	0, 75	18	0, 75	18	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	

$I_C = 4$ mA; $V_{CE} = 10$ V; f = 35 MHz (BF240, BF241)

Input conductance	g_{ie}	typ.	4	mA/V
Input capacitance	C_{ie}	typ.	25	pF
Transfer admittance	$\|y_{fe}\|$	typ.	125	mA/V
Output conductance	g_{oe}	typ.	62	µA/V
Output capacitance	C_{oe}	typ.	1	pF


7Z67062
600
400
200
0
f_T
(MHz)
V_{CE} = 10 V
f = 100 MHz
typ. values
BF240
BF241
0
10
I_C (mA)
20


7Z67060
6
4
2
0
F
(dB)
V_{CE} = 10 V
I_C = 1 mA
R_S = 60 Ω
R_S = 200 Ω
typ. values
BF241
BF240
BF241
BF240
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic envelope especially intended for r.f. stages in f.m. front-ends in common base configuration.

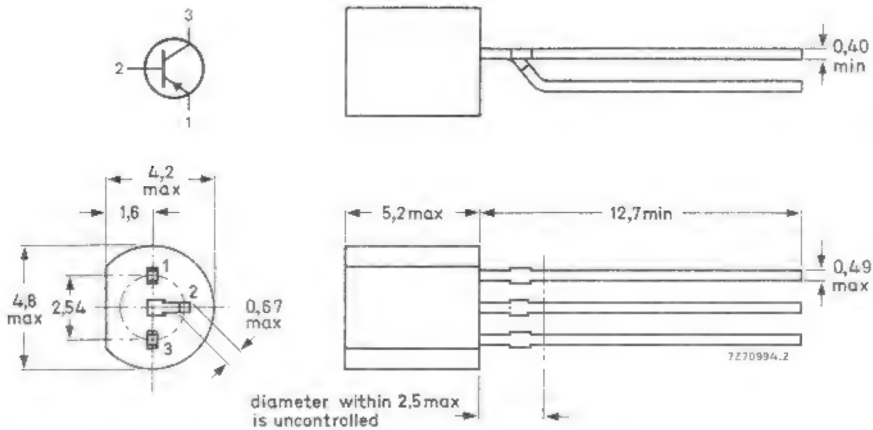
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250 mW
Junction temperature	T_j	max.	150 °C
Base current $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	$-I_B$	typ. >	80 μA 160 μA
Transition frequency $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	f_T	typ.	450 MHz
Noise figure at f = 100 MHz $-I_C$ = 2 mA; $-V_{CE}$ = 10 V; G_s = 16,7 mA/V	F	typ.	3 dB
Feedback capacitance at f = 1 MHz V_{EB} = 0; $-V_{CB}$ = 10 V	C_{rb}	typ.	0,1 pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

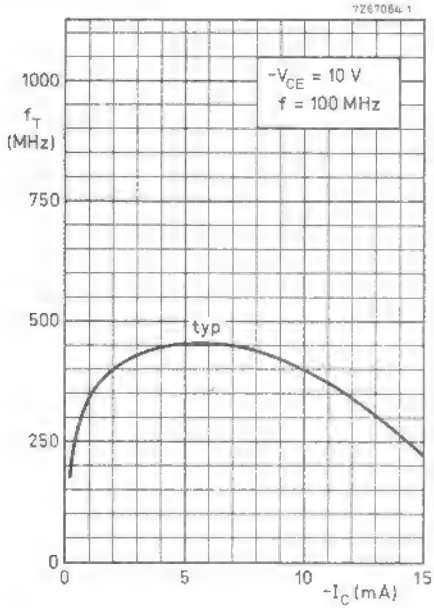
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
→ Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

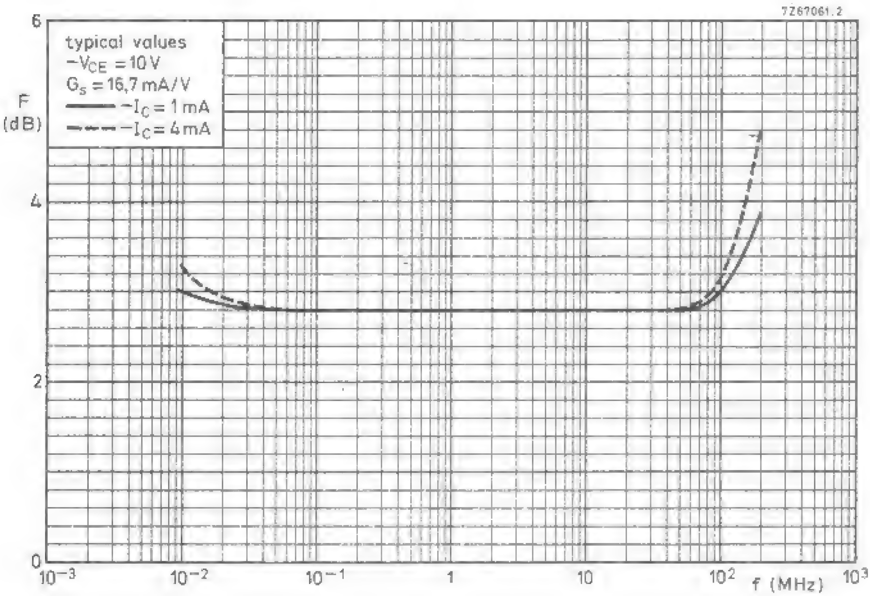
THERMAL RESISTANCE

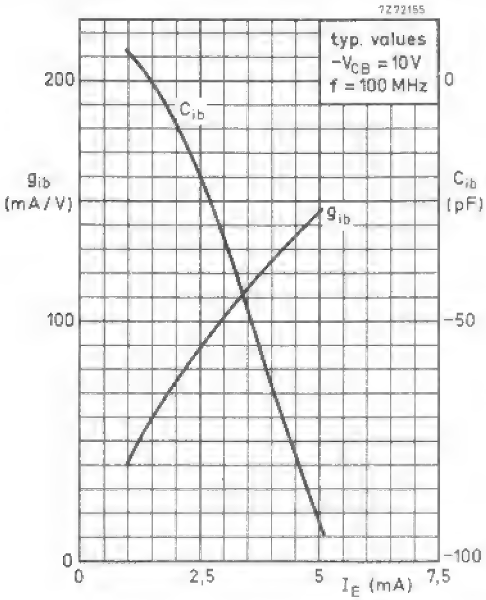
→ From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420	K/W

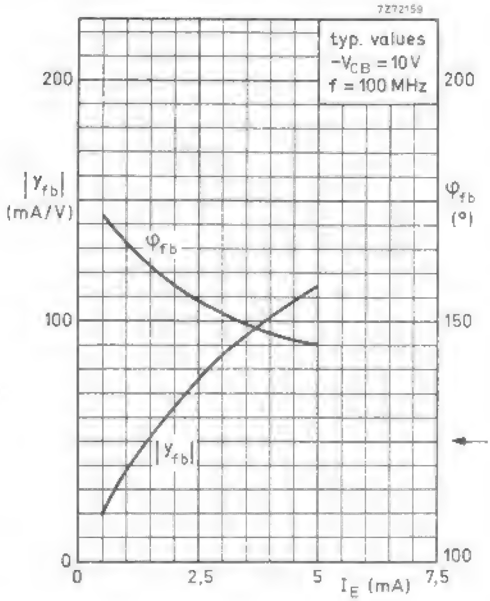
CHARACTERISTICS $T_j = 25\ ^{o}C$

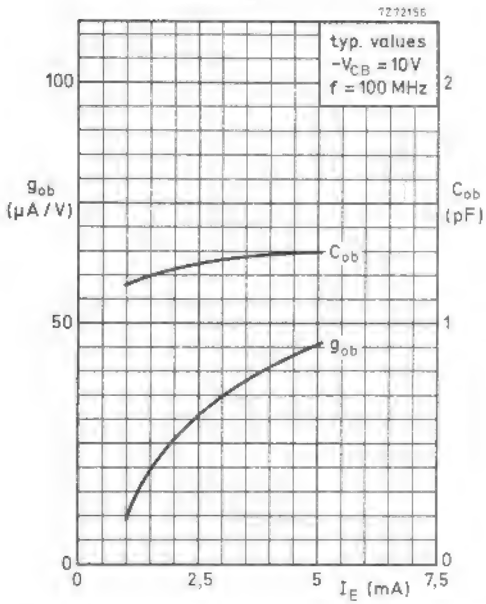
Collector cut-off current				
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA
Base current				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-I_B$	typ. <</br>	80 160	μA μA
$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	22	μA
Base-emitter voltage				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,76	V
Transition frequency at f = 100 MHz				
$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	350	MHz
$-I_C = 4$ mA; $-V_{CE} = 10$ V	f_T	typ.	450	MHz
$-I_C = 8$ mA; $-V_{CE} = 10$ V	f_T	typ.	440	MHz
Feedback capacitance at f = 1 MHz				
$V_{EB} = 0; -V_{CB} = 10$ V	C_{rb}	typ.	0,1	pF
Noise factor at f = 100 MHz				
$-I_C = 2$ mA; $-V_{CE} = 10$ V; $G_S = 16,7$ mA/V	F	typ.	3	dB
$-I_C = 5$ mA; $-V_{CE} = 10$ V; $G_S = 6,7$ mA/V; $-jB_S = 5$ mA/V	F	typ.	3,5	dB
y-parameters (common base) at f = 100 MHz				
$-I_C = 4$ mA; $-V_{CB} = 10$ V				
Input conductance	g_{ib}	typ.	125	mA/V
Input capacitance	$-C_{ib}$	typ.	64	pF
Transfer admittance	$\|y_{fb}\|$	typ.	100	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	147°	
Output conductance	g_{ob}	typ.	40	μA/V
Output capacitance	C_{ob}	typ.	1,25	pF
Feedback admittance	$\|y_{rb}\|$	typ.	220	μA/V
Phase angle of feedback admittance	$-\varphi_{rb}$	typ.	85°	

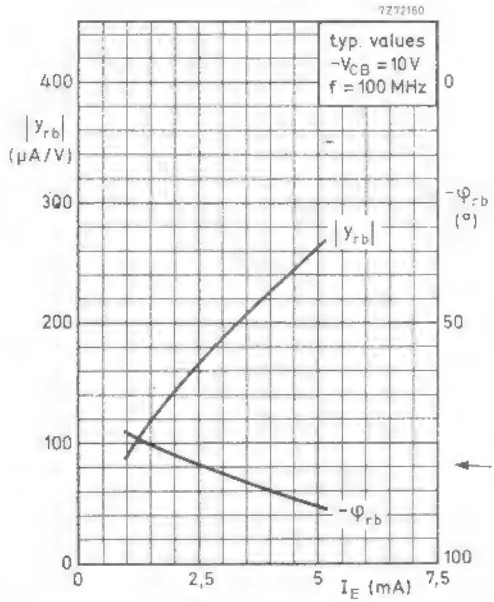

7Z67064.1
$-V_{CE}$ = 10 V
f = 100 MHz
f_T (MHz)
typ
1000
750
500
250
0
0
5
10
15
$-I_C$ (mA)

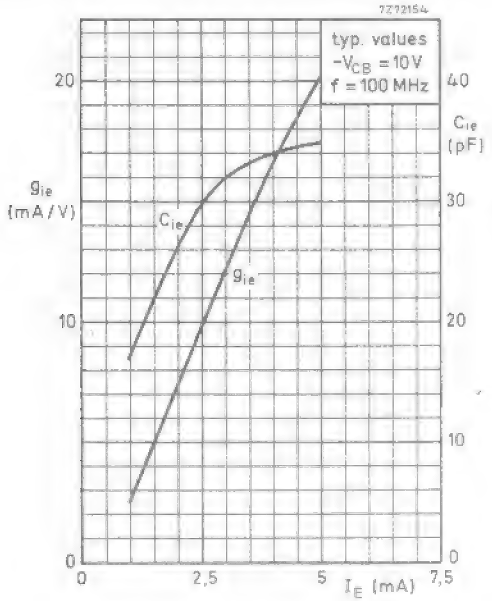

7Z67061.2
typical values
$-V_{CE}$ = 10 V
G_s = 16,7 mA/V
$-I_C$ = 1 mA
$-I_C$ = 4 mA
F (dB)
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
f (MHz)

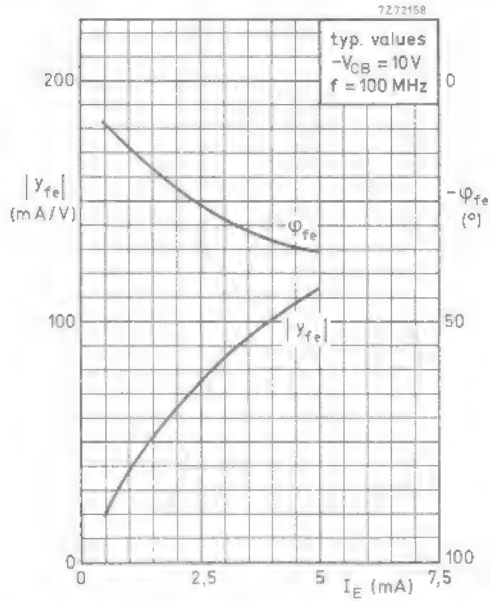

7Z72155
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
g_{ib} (mA/V)
C_{ib} (pF)
C_{ib}
g_{ib}
I_E (mA)

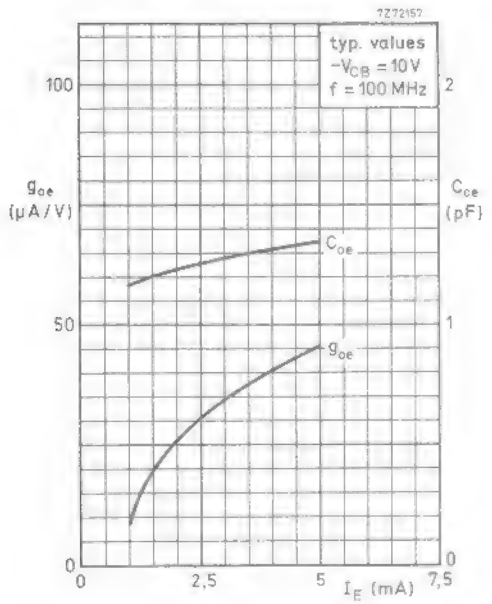

7Z72159
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
$|y_{fb}|$ (mA/V)
φ_{fb} (°)
φ_{fb}
$|y_{fb}|$
I_E (mA)

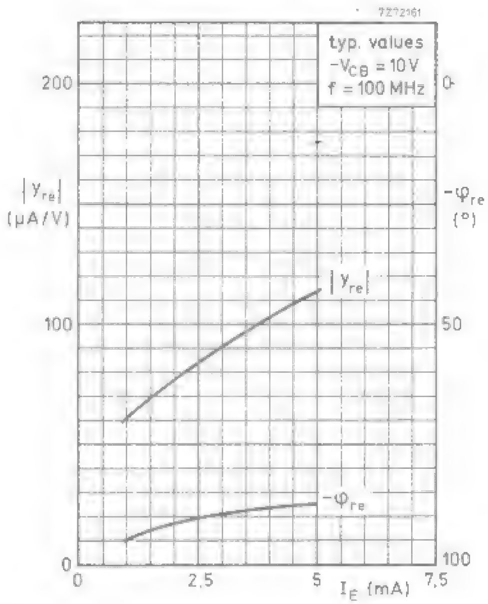

7Z72156
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
g_{ob} (μA/V)
C_{ob} (pF)
C_{ob}
g_{ob}
I_E (mA)


7Z72160
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
$|y_{rb}|$ (μA/V)
$-\varphi_{rb}$ (°)
$|y_{rb}|$
$-\varphi_{rb}$
I_E (mA)


7Z72154
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
g_{ie} (mA/V)
C_{ie} (pF)
C_{ie}
g_{ie}
I_E (mA)


7Z72158
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
$|y_{fe}|$ (mA/V)
$-\varphi_{fe}$ (°)
$-\varphi_{fe}$
$|y_{fe}|$
I_E (mA)


7Z72157
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
g_{oe} (µA/V)
C_{oe} (pF)
C_{oe}
g_{oe}
I_E (mA)


7Z72161
typ. values
$-V_{CB} = 10\,V$
f = 100 MHz
$|y_{re}|$ (µA/V)
$-\varphi_{re}$ (°)
$|y_{re}|$
$-\varphi_{re}$
I_E (mA)

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope, intended for use in large-signal handling i.f. pre-amplifiers of TV receivers in combination with surface acoustic wave filters.

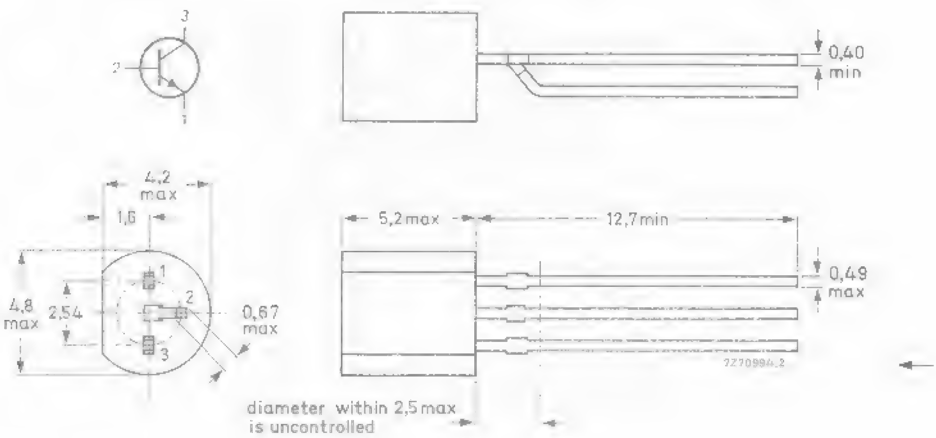
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 100 MHz I_C = 40 mA; V_{CE} = 10 V	f_T	>	490	MHz
Voltage gain at f = 36 MHz (see Fig. 4) I_C = 20 mA; V_{CE} ≈ 10,4 V	G_v	typ.	24	dB
Interference voltage for K = 1% (see Fig. 4)	$V_{(int)rms}$	typ.	120	mV

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40 V
Collector-emitter voltage (open base)	V_{CEO}	max.	15 V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5 V
Collector current (d.c.)	I_C	max.	100 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
→ Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250 K/W

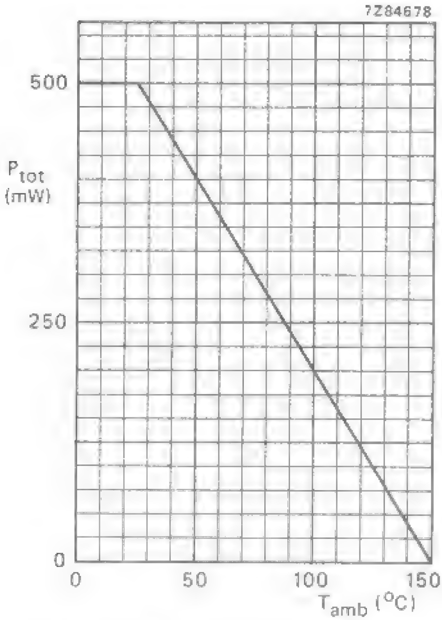


Fig. 2 Power dissipation derating curve as a function of ambient temperature.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400 nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 125$ °C	I_{CBO}	<	30 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 2$ V	I_{EBO}	<	100 nA
D.C. current gain			
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	40
Transition frequency at f = 100 MHz			
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	500 MHz
$I_C = 40$ mA; $V_{CE} = 10$ V	f_T	>	490 MHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ. <</br>	2,2 pF 3,5 pF
Emitter capacitance at f = 1 MHz			
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4,5 pF
Feedback capacitance at f = 1 MHz			
$I_C = 0$; $V_{CE} = 10$ V	C_{re}	typ. <	1,6 pF 2,2 pF

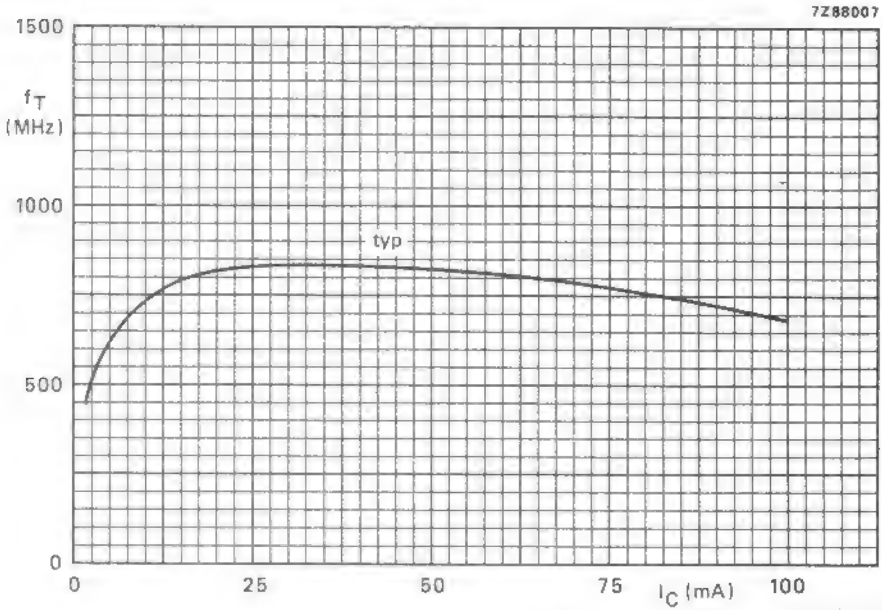
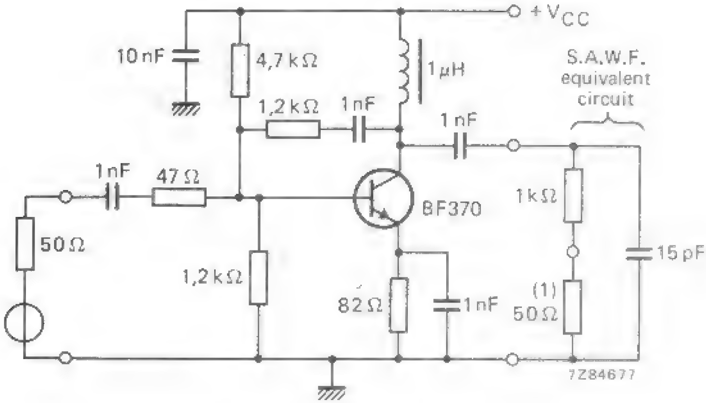


Fig. 3 $V_{CE} = 10$ V; $T_j = 25$ °C.

APPLICATION INFORMATION



(1) Test instrument load.

Fig. 4 Large-signal handling i.f. preamplifier for surface acoustic wave filter.

Performance

Supply voltage	V_{CC}	=	12 V
Collector current	I_C	=	20 mA
Measuring frequency	f_i	=	36 MHz
Input impedance	Z_i	typ.	50 Ω//1 pF
Output impedance	Z_o	<	100 Ω
Voltage gain G_v (in dB) $= 20 \log \frac{V_o}{V_i}$	G_v	typ.	24 dB
Interference voltage for K = 1%*	$V_{(int)rms}$	typ.	120 mV

* Input terminal voltage at 50 Ω internal resistance of signal generator, interference frequency 40 MHz, 80% modulated with 1 kHz.

SILICON EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelope primarily intended for class-B video output stages in colour television and professional monitor equipment. P-N-P complements are BF421 and BF423.

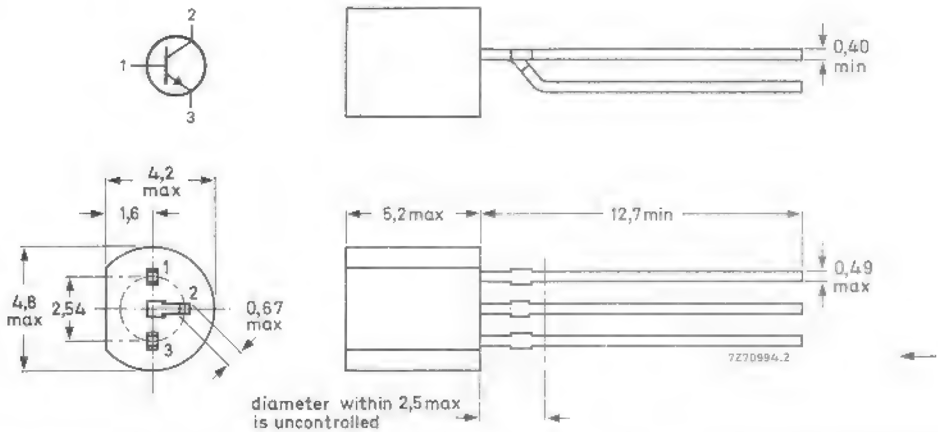
QUICK REFERENCE DATA

			BF420	BF422	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	250	V
Collector-emitter voltage	V_{CER}	max.	300		V
	V_{CEO}	max.		250	V
Collector current (peak value)	I_{CM}	max.	100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	830		mW
Junction temperature	T_j	max.	150		°C
D.C. current gain at T_j = 25 °C I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50		
Transition frequency I_C = 10 mA; V_{CE} = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz I_C = 0; V_{CE} = 30 V	C_{re}	<	1,6		pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BF420	BF422	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	250	V
Collector-emitter voltage					
R_{BE} = 2,7 kΩ	V_{CER}	max.	300		V
I_B = 0	V_{CEO}	max.		250	V

Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C*	P_{tot}	max.	830	mW
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient*	$R_{th\ j\text{-}a}$	=	150	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

			BF420	BF422	
Collector cut-off currents					
$I_E = 0$; V_{CB} = 200 V	I_{CBO}	<	10	10	nA
R_{BE} = 2,7 kΩ; V_{CE} = 200 V; T_j = 150 °C	I_{CER}	<	10	10	μA

Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	10	μA
D.C. current gain				
I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50	
High-frequency knee voltage**				
I_C = 25 mA; T_j = 150 °C	V_{CEK}	typ.	20	V
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	60	MHz
Feedback capacitance at f = 1 MHz				
$I_C = 0$; V_{CE} = 30 V	C_{re}	<	1,6	pF

* Transistor mounted on a printed-circuit board, mounting pad for collector lead minimum 10 mm x 10 mm; maximum length 4 mm.

** The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small-signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

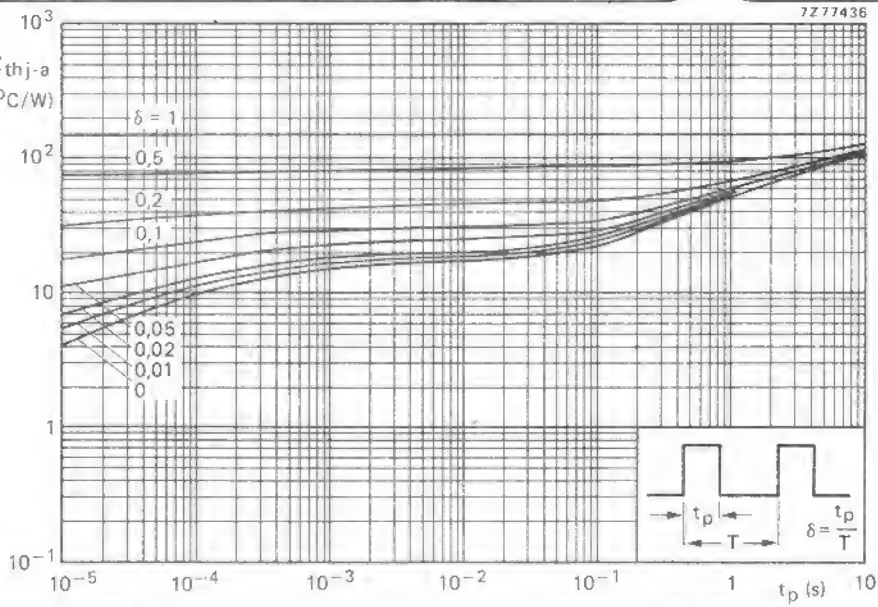


Fig. 2 Thermal impedance from junction to ambient versus pulse duration. Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

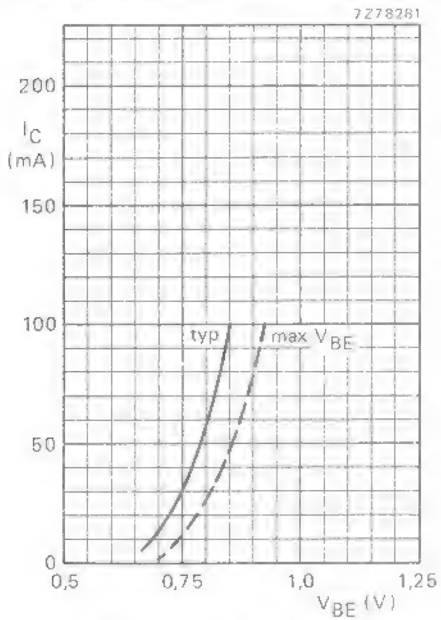


Fig. 3 V_{CE} = 20 V; T_j = 25 °C.

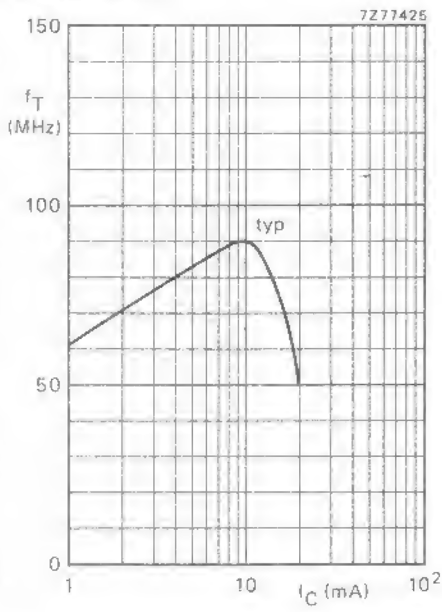


Fig. 4 V_{CE} = 10 V; T_j = 25 °C; f = 35 MHz.

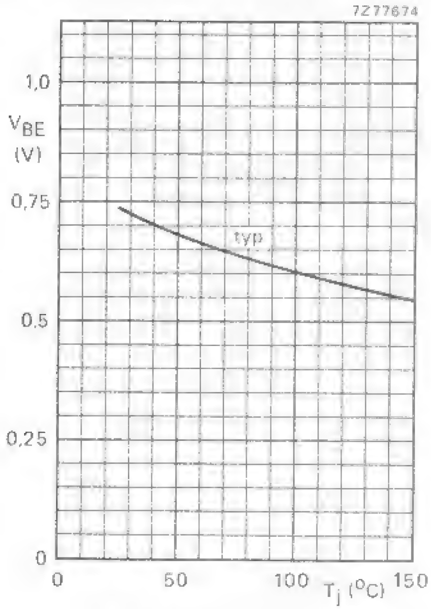


Fig. 5 I_C = 25 mA; V_{CE} = 20 V.

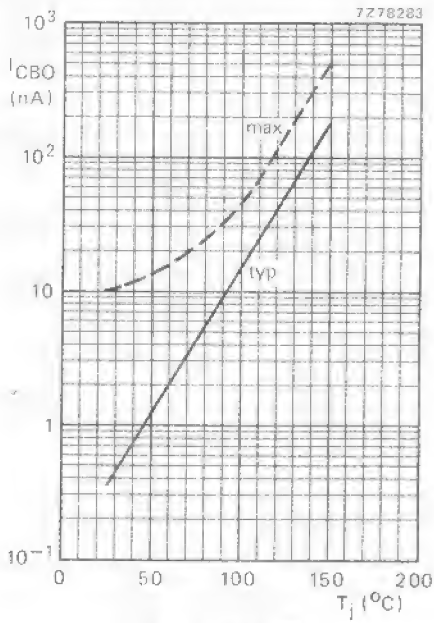


Fig. 6 V_{CB} = 200 V.

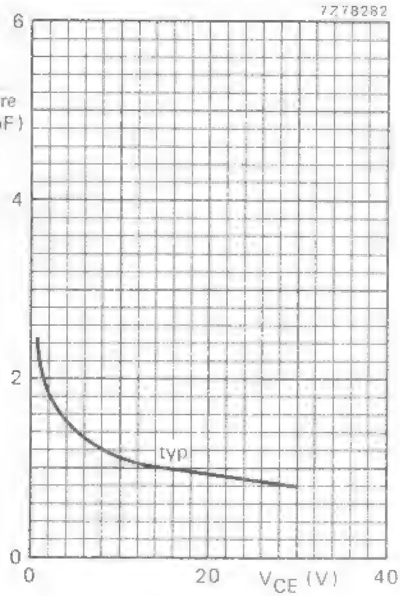


Fig. 7 I_C = 0; f = 1 MHz; T_j = 25 °C.

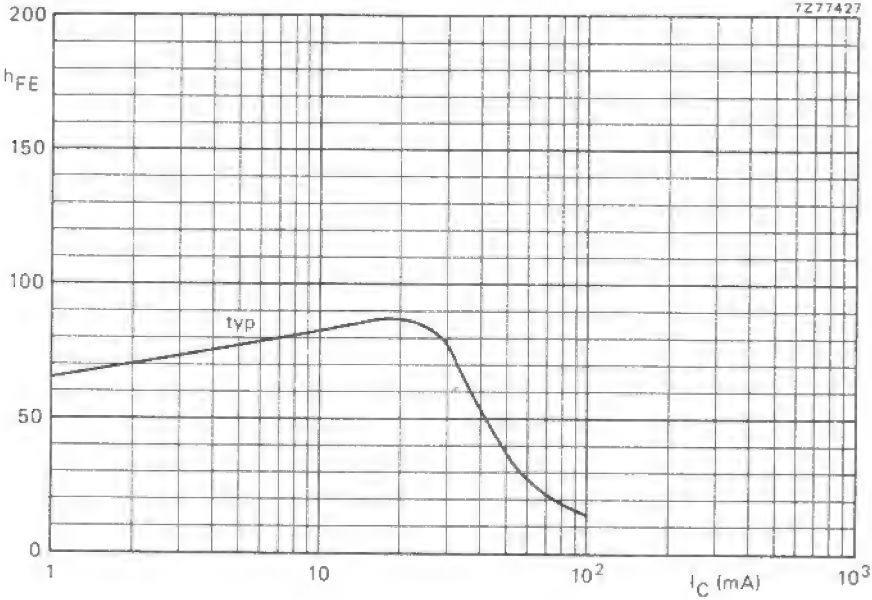


Fig. 8 V_{CE} = 20 V; T_j = 25 °C.

SILICON EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 variant envelope primarily intended for class-B video output stages in colour television and professional monitor equipment. N-P-N complements are BF420 and BF422.

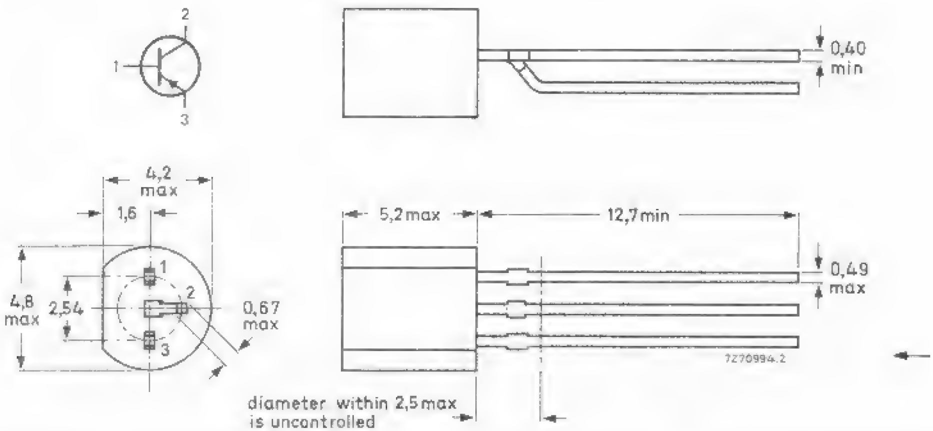
QUICK REFERENCE DATA

			BF421	BF423	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage	$-V_{CER}$	max.	300		V
	$-V_{CEO}$	max.		250	V
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	830		mW
Junction temperature	T_j	max.	150		°C
D.C. current gain at T_j = 25 °C $-I_C$ = 25 mA; $-V_{CE}$ = 20 V	h_{FE}	>	50		
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz $-I_C$ = 0; $-V_{CE}$ = 30 V	C_{re}	<	1,6		pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BF421	BF423	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage					
$R_{BE} = 2,7\ k\Omega$	$-V_{CER}$	max.	300		V
$I_B = 0$	$-V_{CEO}$	max.		250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current (d.c.)	$-I_C$	max.	50		mA
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to $T_{amb} = 25\ ^oC$*	P_{tot}	max.	830		mW
Storage temperature	T_{stg}		−65 to + 150		^oC
Junction temperature	T_j	max.	150		^oC

THERMAL RESISTANCE

From junction to ambient*	$R_{th\ j\text{-}a}$	=	150	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified.

			BF421	BF423	
Collector cut-off currents					
$I_E = 0; -V_{CB} = 200$ V	$-I_{CBO}$	<	10	10	nA
$R_{BE} = 2,7\ k\Omega; -V_{CE} = 200$ V; $T_j = 150\ ^oC$	$-I_{CER}$	<	10	10	μA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10		μA
D.C. current gain					
$-I_C = 25$ mA; $-V_{CE} = 20$ V	h_{FE}	>	50		
High-frequency knee voltage**					
$-I_C = 25$ mA; $T_j = 150\ ^oC$	$-V_{CEK}$	typ.	20		V
Transition frequency					
$-I_C = 10$ mA; $-V_{CE} = 10$ V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz					
$-I_C = 0; -V_{CE} = 30$ V	C_{re}	<	1,6		pF

* Transistor mounted on a printed-circuit board, mounting pad for collector lead minimum 10 mm x 10 mm; maximum length 4 mm.

** The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small-signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

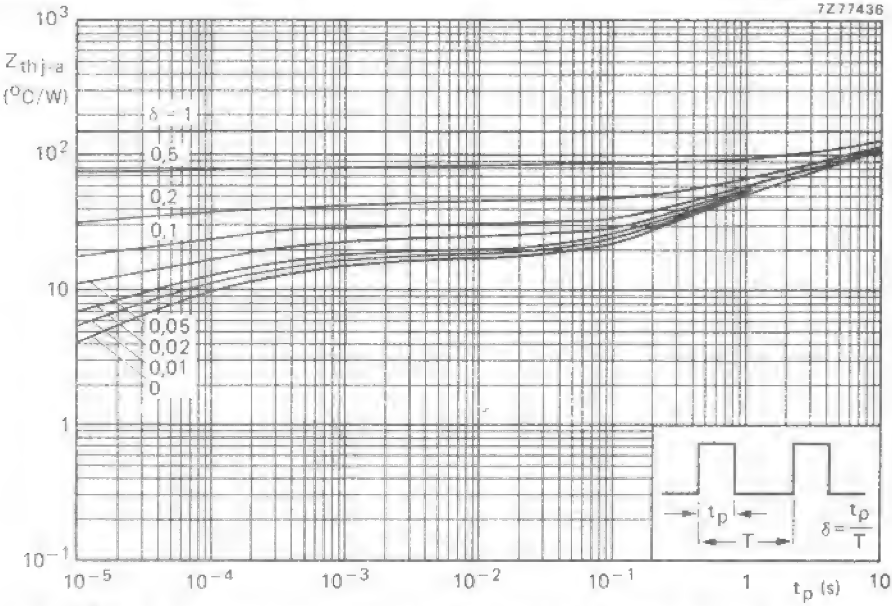


Fig. 2 Thermal impedance from junction to ambient versus pulse duration. Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

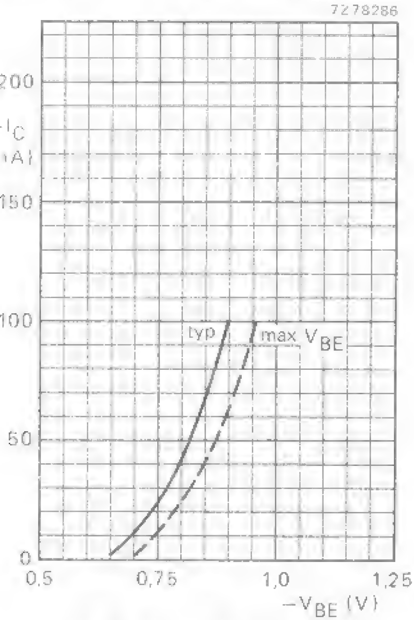


Fig. 3 $-V_{CE}$ = 20 V; T_j = 25 ^oC.

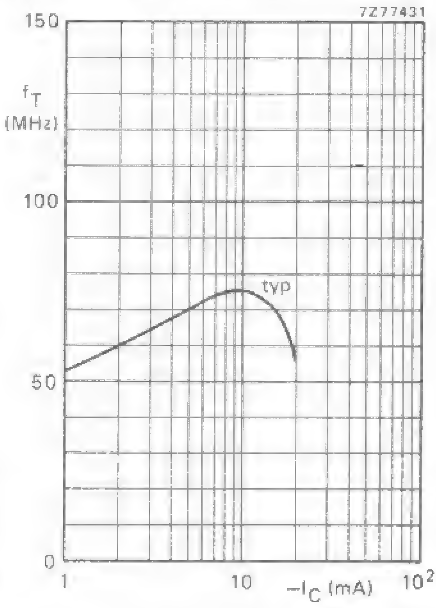


Fig. 4 $-V_{CE}$ = 10 V; T_j = 25 ^oC; f = 35 MHz.

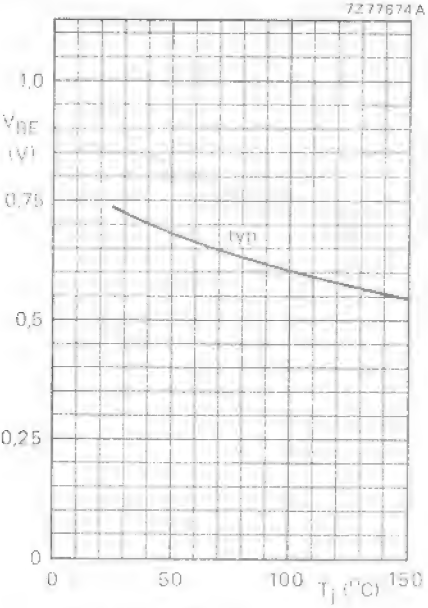


Fig. 5 $-I_C$ = 25 mA; $-V_{CE}$ = 20 V.

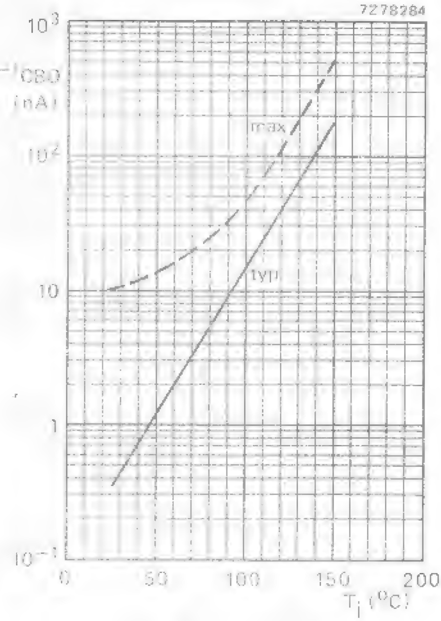


Fig. 6 $-V_{CB}$ = 200 V.

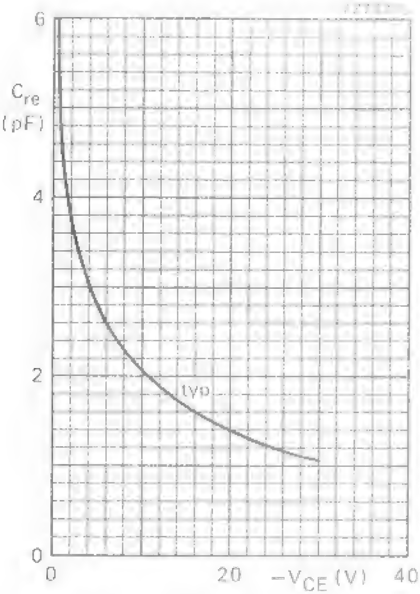


Fig. 7 I_C = 0; f = 1 MHz; T_j = 25 °C.

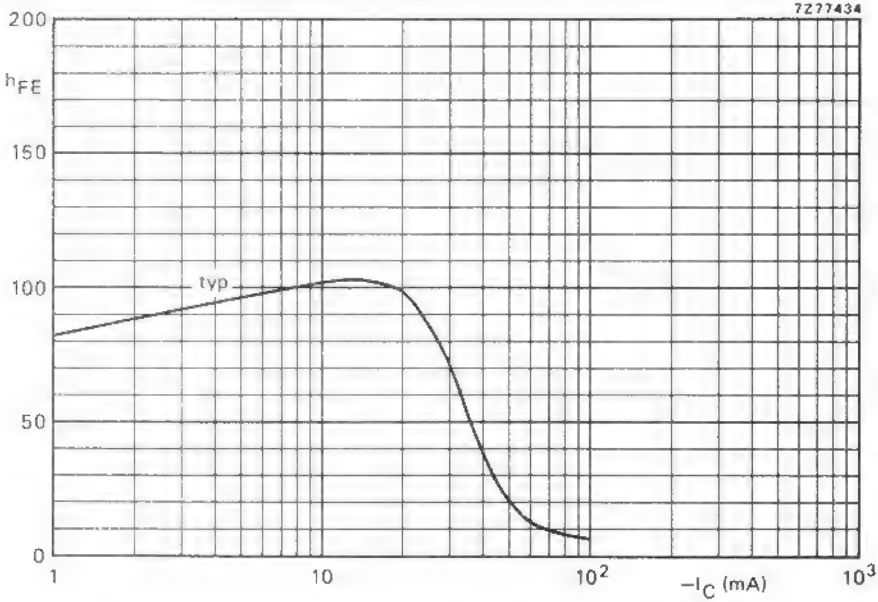


Fig. 8 Typical values at $-V_{CE}$ = 20 V; T_j = 25 °C.

H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope intended for h.f. and i.f. applications in radio receivers, especially for mixer stages in a.m. receivers and i.f. stages in a.m./f.m. receivers with negative earth.

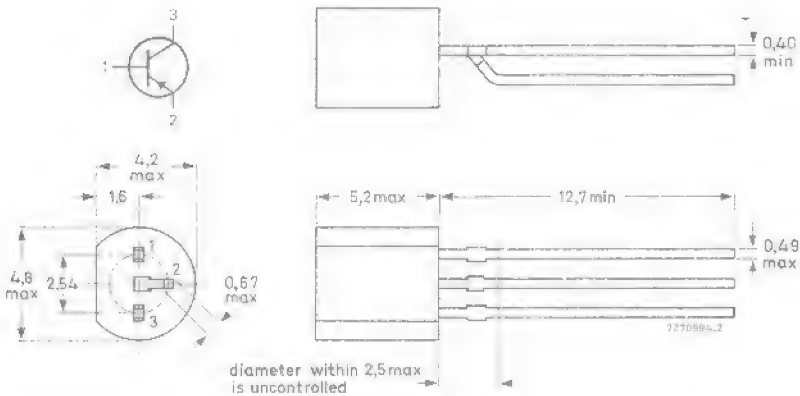
QUICK REFERENCE DATA

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)		$-V_{CEO}$	max.	40 V
Collector current (d.c.)		$-I_C$	max.	25 mA
Total power dissipation up to T_{amb} = 45 °C		P_{tot}	max.	250 mW
Junction temperature		T_j	max.	150 °C
Base current $-I_C$ = 1 mA; $-V_{CE}$ = 10 V	BF450:	$-I_B$		5 to 16 μA
	BF451:	$-I_B$		11 to 33 μA
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 10 V		f_T	typ.	325 MHz
Noise figure at f = 100 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 10 V; R_S = 300 Ω		F	typ.	2 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
→ Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

→ From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	420	K/W

CHARACTERISTICS

T_j = 25 °C

Collector cut-off current					
$I_E = 0; -V_{CB} = 30$ V		$-I_{CBO}$	<	50	nA
$I_E = 0; -V_{CB} = 40$ V		$-I_{CBO}$	<	10	µA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 4$ V		$-I_{EBO}$	<	10	µA
Base current					
$-I_C = 1$ mA; $-V_{CE} = 10$ V	BF450	$-I_B$	<	5 to 16	µA
	BF451	$-I_B$	<	11 to 33	µA
Base-emitter voltage					
$-I_C = 1$ mA; $-V_{CE} = 10$ V		$-V_{BE}$	typ.	700	mV

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 100 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	325	MHz

Feedback capacitance at f = 1 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	C_{re}	typ.	0,35	pF

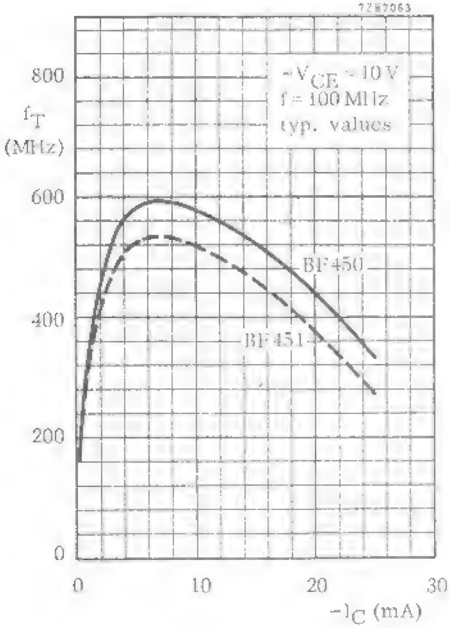
Noise figure at f = 100 kHz

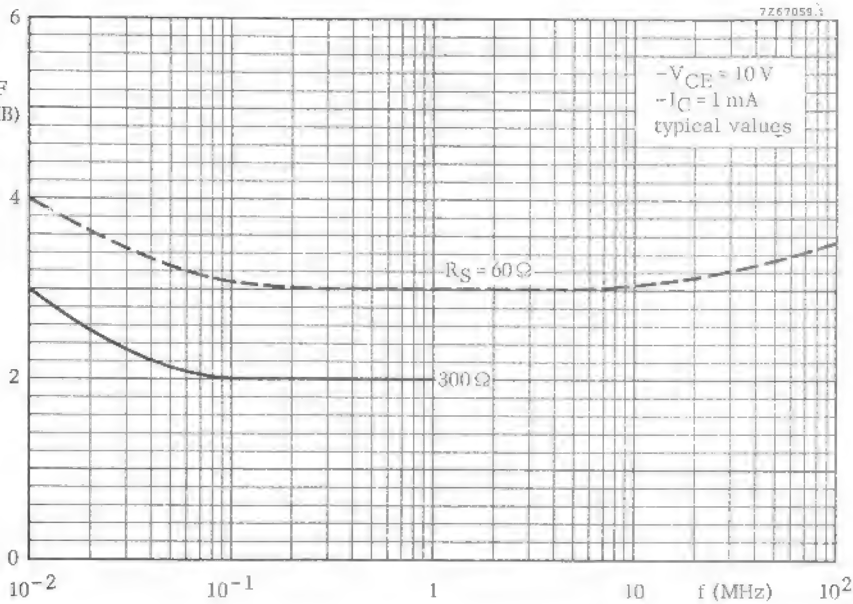
$-I_C = 1$ mA; $-V_{CE} = 10$ V; $R_S = 300\ \Omega$	F	typ.	2	dB

y-parameters (common emitter)

$-I_C = 1$ mA; $-V_{CE} = 10$ V

			BF450		BF451		
	f	=	0,45	10,7	0,45	10,7	MHz
Input conductance	g_{ie}	typ.	0,3	0,4	0,7	0,8	mA/V
Input capacitance	C_{ie}	typ.	20	13	30	20	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	typ.	8	10	8	10	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	1	24	1	24	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	


7Z67063
$-V_{CE} = 10$ V
f = 100 MHz
typ. values
f_T
(MHz)
800
600
400
200
0
BF450
BF451
0
10
20
30
$-I_C$ (mA)


7Z67059.1
$-V_{CE} = 10$ V
$-I_C = 1$ mA
typical values
F
(dB)
6
4
2
0
$R_S = 60\,\Omega$
$300\,\Omega$
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-92 variant envelope and intended for use in video output stages in black-and-white and in colour television receivers.

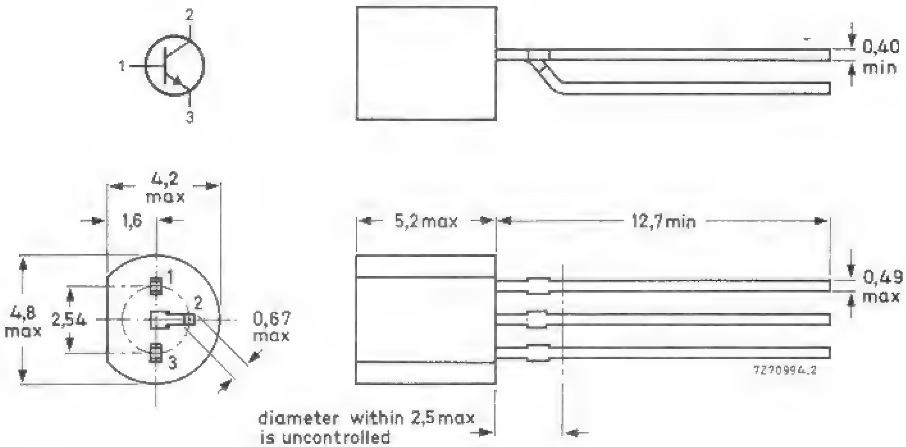
QUICK REFERENCE DATA

			BF483	BF485	BF487	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	350	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	300	350	V
Collector current (peak value)	I_{CM}	max.		100		mA
Total power dissipation (free air)	P_{tot}	max.		830		mW
D.C. current gain I_C = 25 mA; V_{CE} = 20 V	h_{FE}	$\geq$		50		
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T			70 to 110		MHz
Junction temperature	T_j	max.		150		°C

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BF483	BF485	BF487	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	350	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	300	350	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current						
d.c.	I_C	max.		50		mA
peak value	I_{CM}	max.		100		mA
Total power dissipation in free air up to T_{amb} = 25 °C	P_{tot}	max.		830		mW
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient when mounted on a p.c. board and mounting pad for collector lead minimum 10 mm x 10 mm and maximum lead length 4 mm	$R_{th\ j\text{-}a}$	max.	150	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current $I_E = 0$; V_{CB} = 300 V	I_{CBO}	$\leqslant$	20	nA
Collector-emitter cut-off current V_{CE} = 250 V; R_{BE} = 2,7 kΩ; T_j = 150 °C	I_{CER}	$\leqslant$	20	µA
Emitter cut-off current $I_C = 0$; V_{EB} = 5 V	I_{EBO}	$\leqslant$	10	µA
High-frequency knee voltage I_C = 25 mA; T_j = 150 °C	V_{CEK}	=	20	V
D.C. current gain I_C = 25 mA; V_{CE} = 20 V	h_{FE}	$\geqslant$	50	
I_C = 40 mA; V_{CE} = 20 V	h_{FE}	$\geqslant$	20	
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T		70 to 110	MHz
Feedback capacitance at f = 1 MHz $I_E = 0$; V_{CB} = 30 V	C_{re}	$\leqslant$	1,4	pF

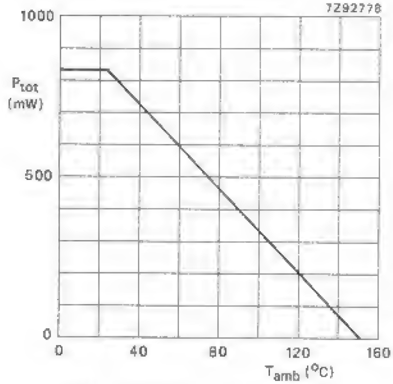


Fig. 2 Maximum permissible power dissipation.

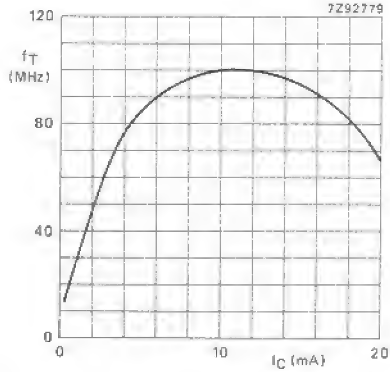


Fig. 3 V_{CE} = 10 V; f = 100 MHz; typical values.

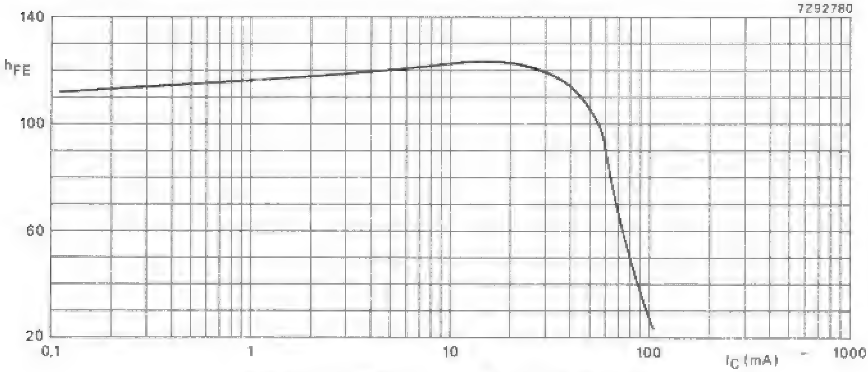


Fig. 4 T_j = 25 °C; V_{CE} = 20 V; typical values.

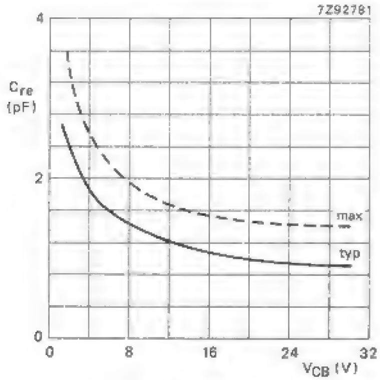


Fig. 5 I_E = 0; f = 1 MHz.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

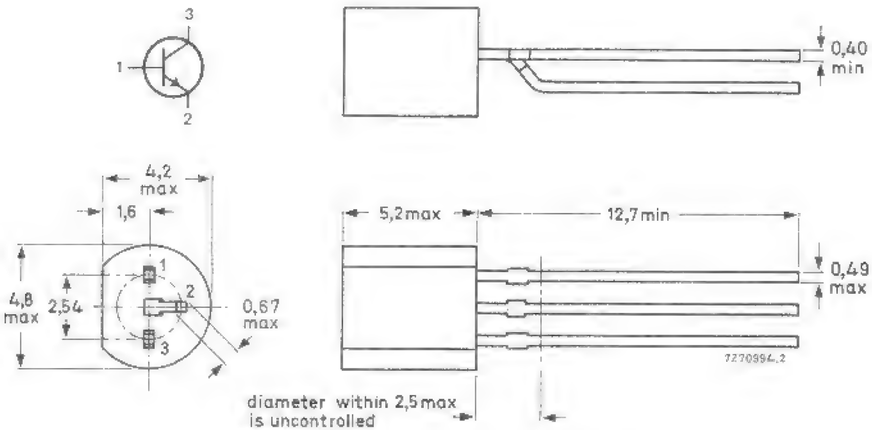
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	20 V
Collector current (d.c.)	I_C	max.	30 mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300 mW
Junction temperature	T_j	max.	150 °C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	115
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260 MHz
Noise figure at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 10 mA/V	F	typ.	4 dB
Conversion noise figure at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 1,2 mA/V	F_c	typ.	2 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS

T_j = 25 °C

Base-emitter voltage [1] I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74	V
Base current I_C = 1 mA; V_{CE} = 10 V [2]	I_B	 typ.	4,5 to 15 8,7	µA µA
Feedback capacitance at f = 0,45 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85	pF

1) V_{BE} decreases by about 1,7 mV/K with increasing temperature.

2) BF494B I_B 4,5 to 10 µA

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 2$ mA/V; f = 0,2 MHz	F	typ.	1,5	dB
$G_S = 1,5$ mA/V; f = 1,0 MHz	F	typ.	1,2	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

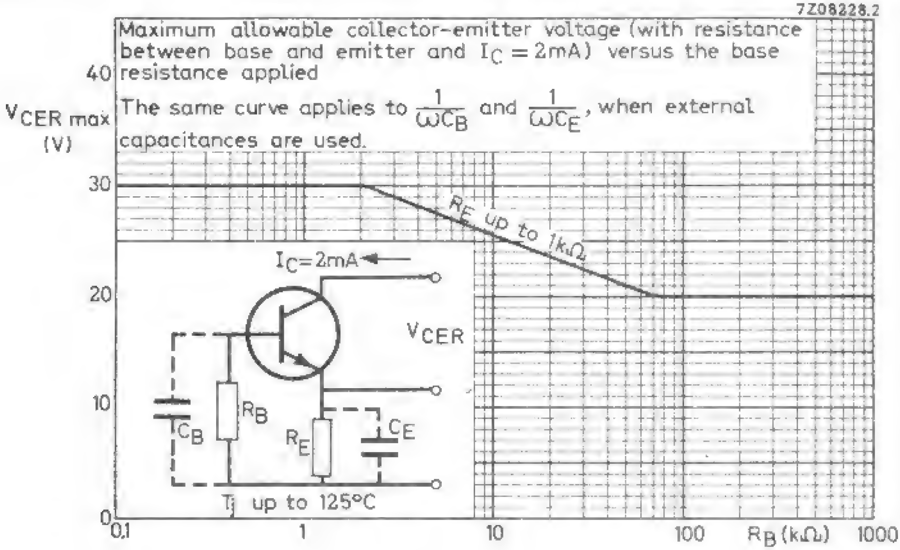
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 0,6$ mA/V; f = 0,2 MHz	F_c	typ.	3	dB
$G_S = 1,2$ mA/V; f = 1,0 MHz	F_c	typ.	2	dB

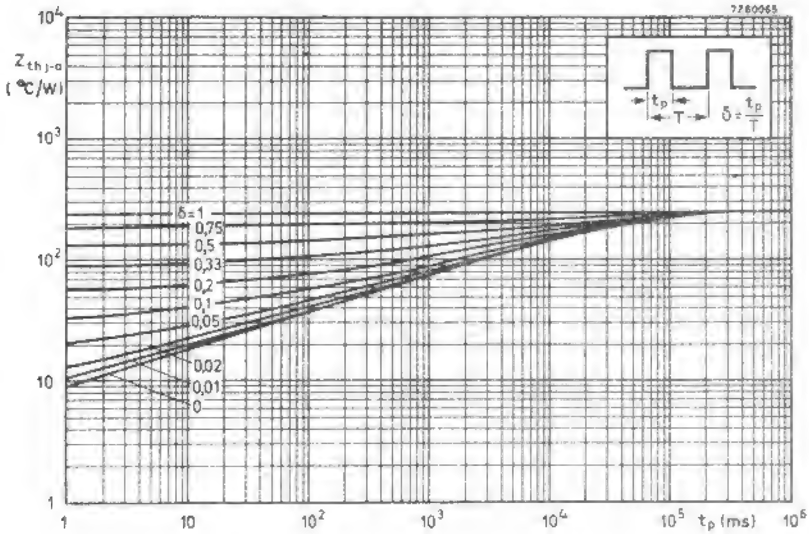
y parameters at f = 100 MHz (common base)

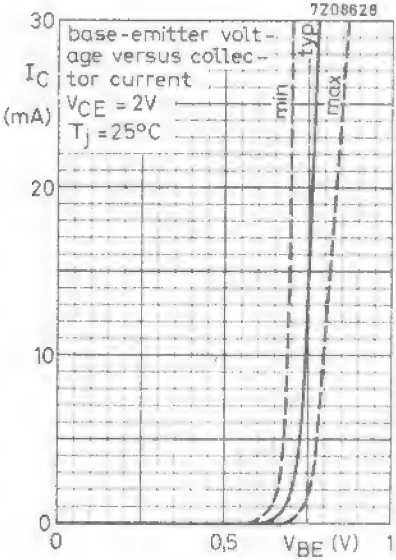
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	32	mA/V
Input susceptance	$-b_{ib}$	typ.	3	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	μA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\|y_{fb}\|$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150^o	
Output conductance	g_{ob}	typ.	22	μA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

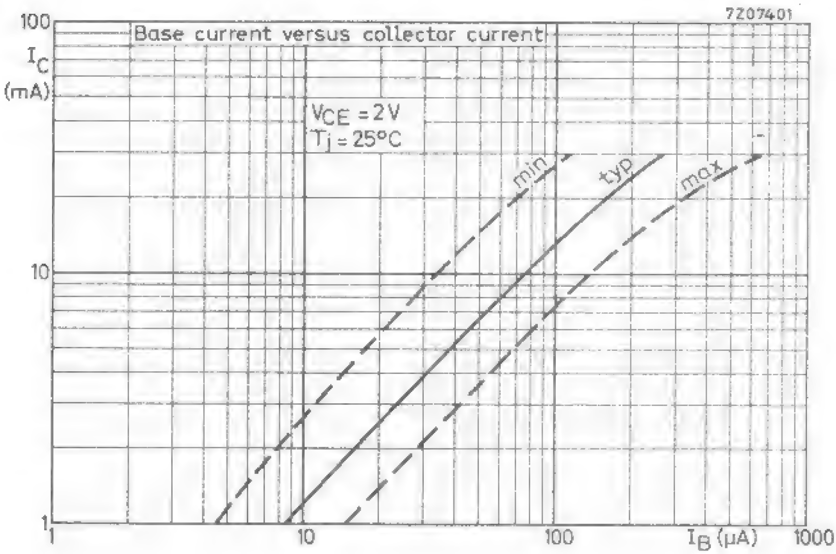
y parameters (common emitter)

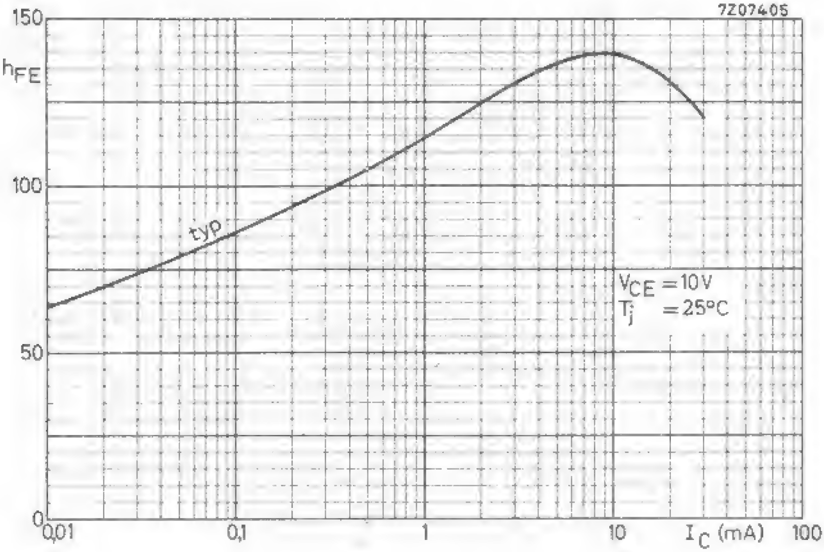
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10,7 MHz		f = 0,45 MHz	
Input conductance	g_{ie}	<	0,64	0,54	mA/V
Output conductance	g_{oe}	<	13,5	11,5	μA/V

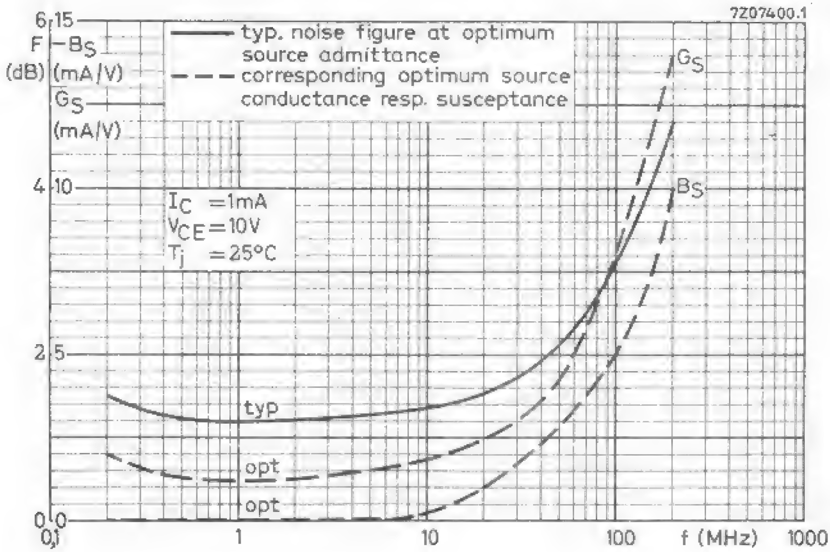

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)

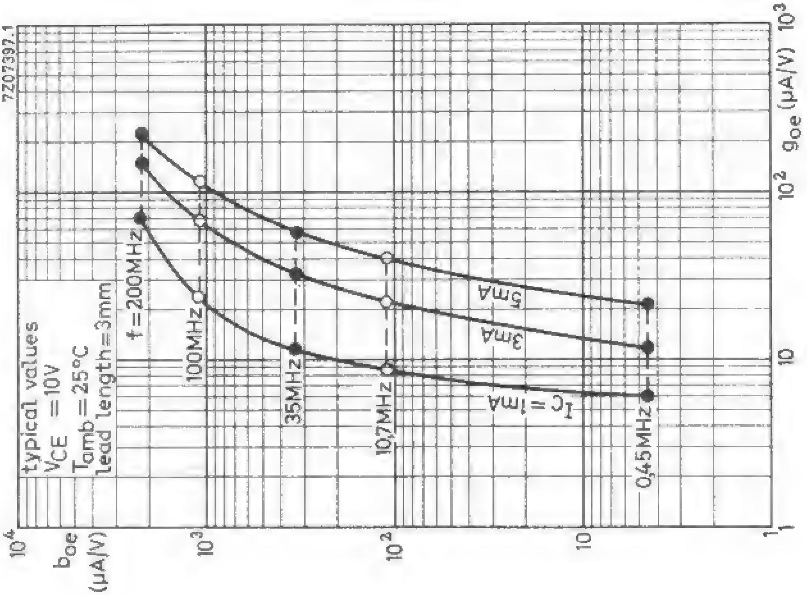

7Z60065
$Z_{th\,j\text{-}a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)

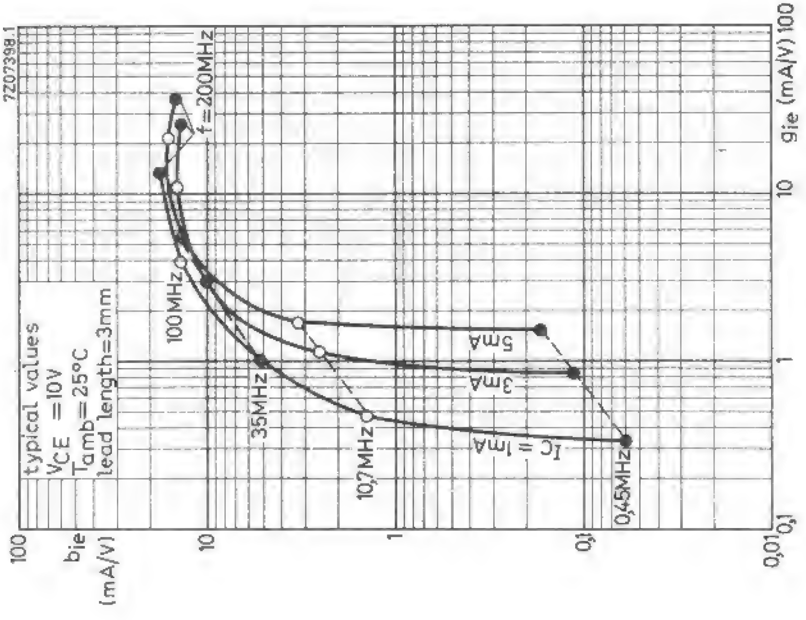

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
min
typ
max
30
20
10
0
I_C
(mA)
0
0,5
V_{BE} (V)
1

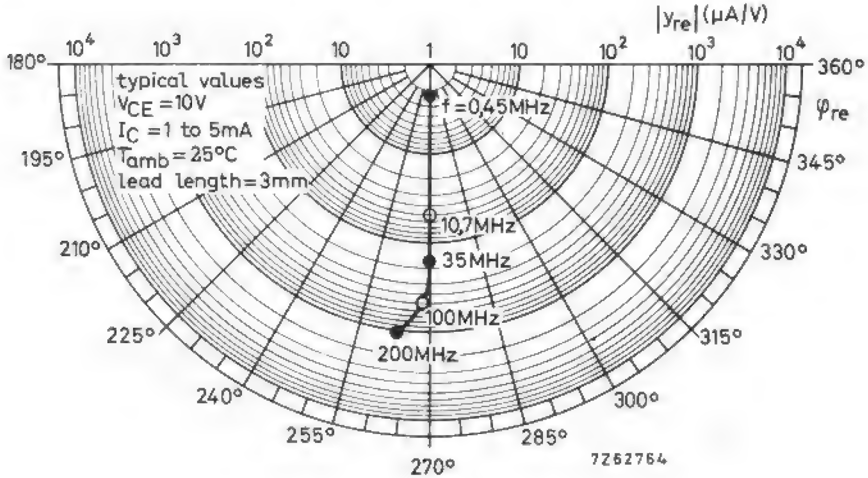

7Z07401
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
min
typ
max
100
10
1
I_C
(mA)
1
10
100
I_B (μA)
1000


7Z07405
h_{FE}
150
100
50
0
typ
V_{CE} = 10 V
T_j = 25°C
0,01
0,1
1
10
100
I_C (mA)

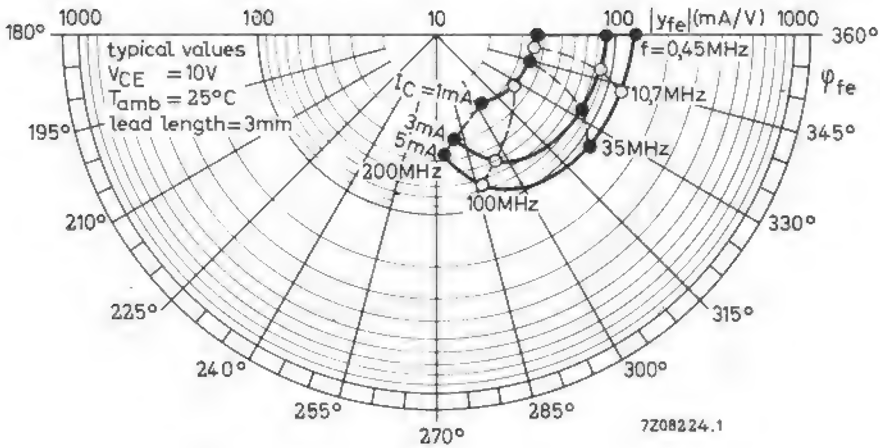

7Z07400.1
F
(dB)
$-B_S$
(mA/V)
G_S
(mA/V)
6 15
4 10
2 5
0 0
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
I_C = 1 mA
V_{CE} = 10 V
T_j = 25°C
G_S
B_S
typ
opt
opt
0,1
1
10
100
1000
f (MHz)


7Z07397.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{oe} (μA/V)
g_{oe} (μA/V)


7Z07398.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{ie} (mA/V)
g_{ie} (mA/V)



|yre| (μA/V)
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4
180°
360°
φre
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
7Z62764



1000
100
10
100
|yfe| (mA/V)
1000
180°
360°
φfe
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
7Z08224.1

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of car radios where a low noise figure at low source impedance is required.

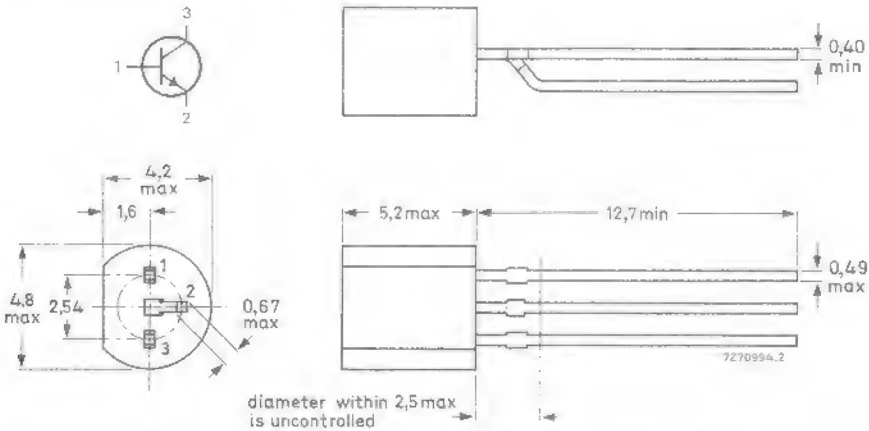
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	30 V
Collector current (d.c.)	I_C	max.	30 mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300 mW
Junction temperature	T_j	max.	150 °C
D.C. current gain at T_j = 25 °C			
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	67
Transition frequency			
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	200 MHz
Noise figure			
I_C = 1 mA; V_{CE} = 10 V			
G_S = 20 mA/V; f = 1 MHz	F	typ.	3,5 dB
G_S = 10 mA/V; f = 100 MHz	F	typ.	4 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	20 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	30 mA
Collector current (peak value)	I_{CM}	max.	30 mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300 mW
Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25 °C/mW

CHARACTERISTICS

T_j = 25 °C

Base-emitter voltage 1)			
I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74 V
Base current			
I_C = 1 mA; V_{CE} = 10 V 2)	I_B		8 to 28 μA
		typ.	15 μA
Feedback capacitance at f = 0,45 MHz			
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85 pF

1) V_{BE} decreases by about 1,7 mV/K with increasing temperature.

2)

BF495C	I_B	8 to 15 μA
BF495D	I_B	13 to 28 μA

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20$ mA/V; f = 1 MHz	F	typ.	3,5	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

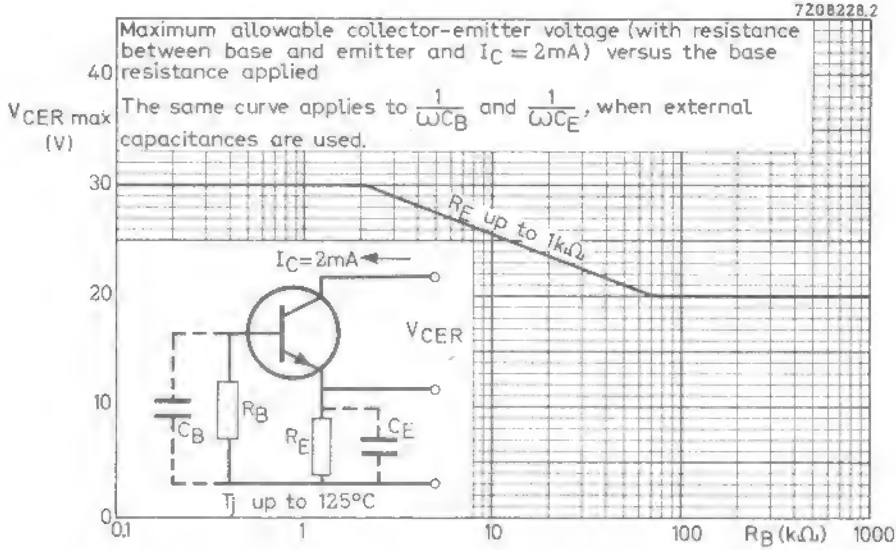
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1,2$ mA/V; f = 0,2 MHz	F_c	typ.	4	dB
$G_S = 1,5$ mA/V; f = 1 MHz	F_c	typ.	2,5	dB

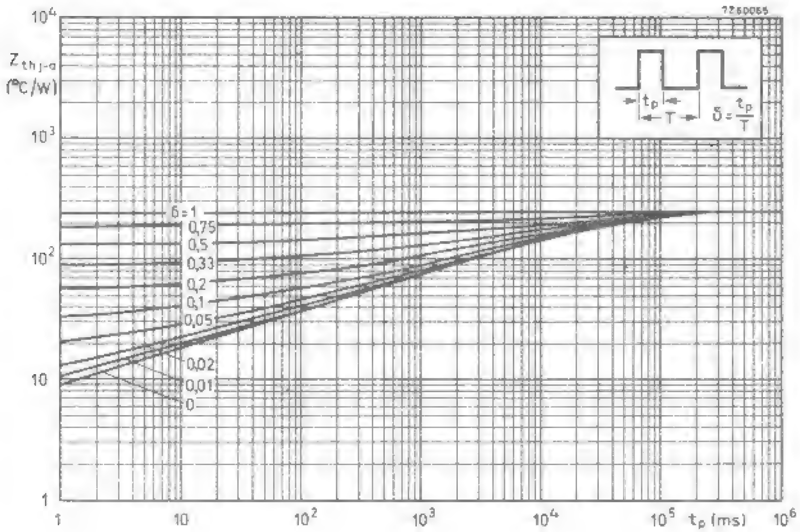
y parameters at f = 100 MHz (common base)

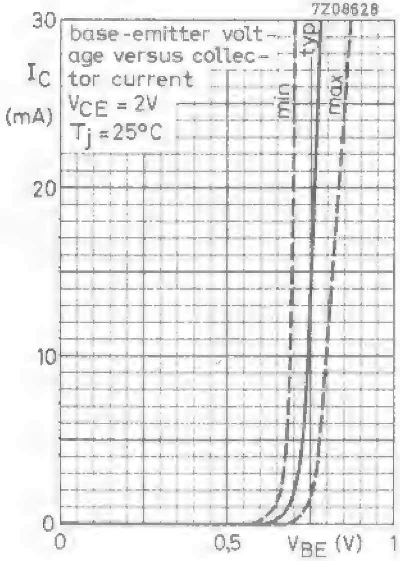
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	34	mA/V
Input susceptance	$-b_{ib}$	typ.	1	mA/V
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	490	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	34	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	144^o	
Output conductance	g_{ob}	typ.	12	µA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

y parameters (common emitter)

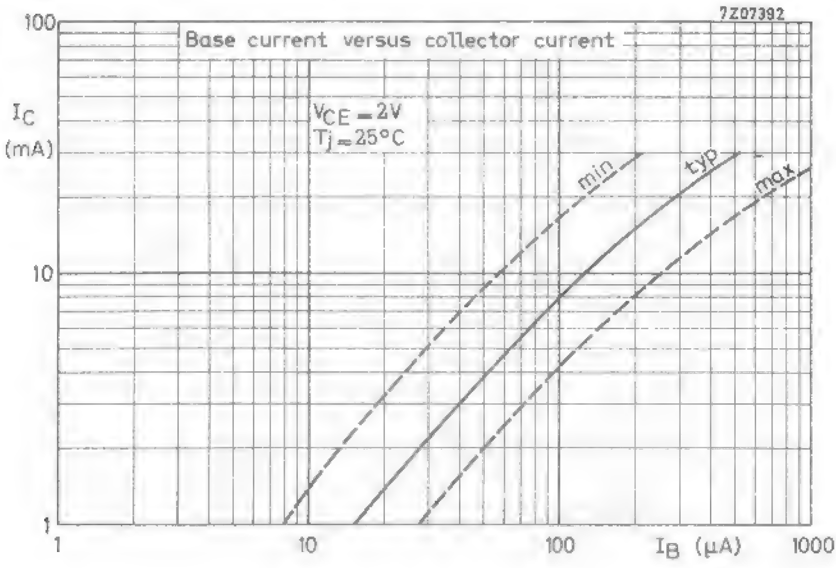
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	<	0,96	0,86	mA/V
Output conductance	g_{oe}	<	9,5	7,0	µA/V


7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
RE up to 1kΩ
I_C=2mA
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)

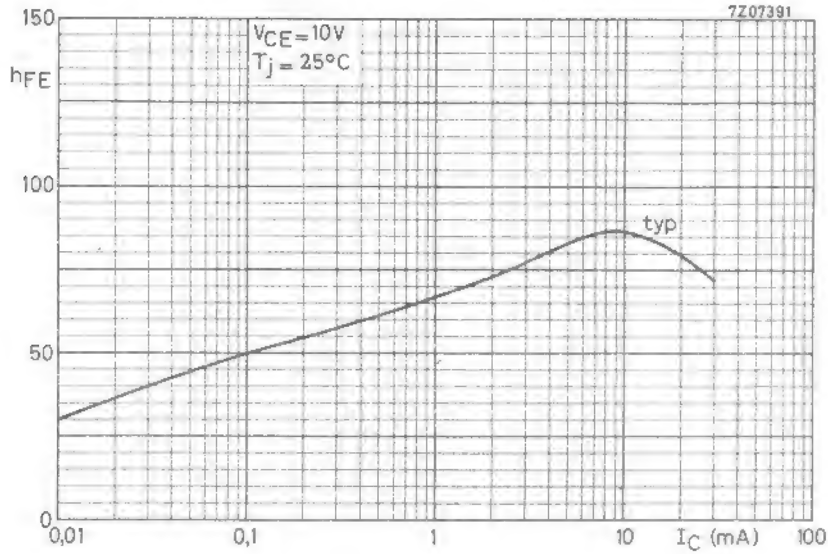

$Z_{th\,j\text{-}a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)

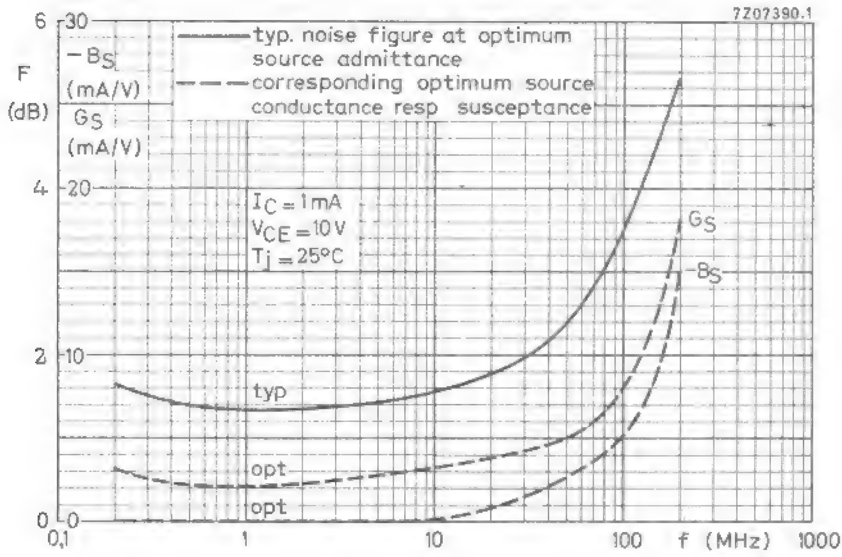


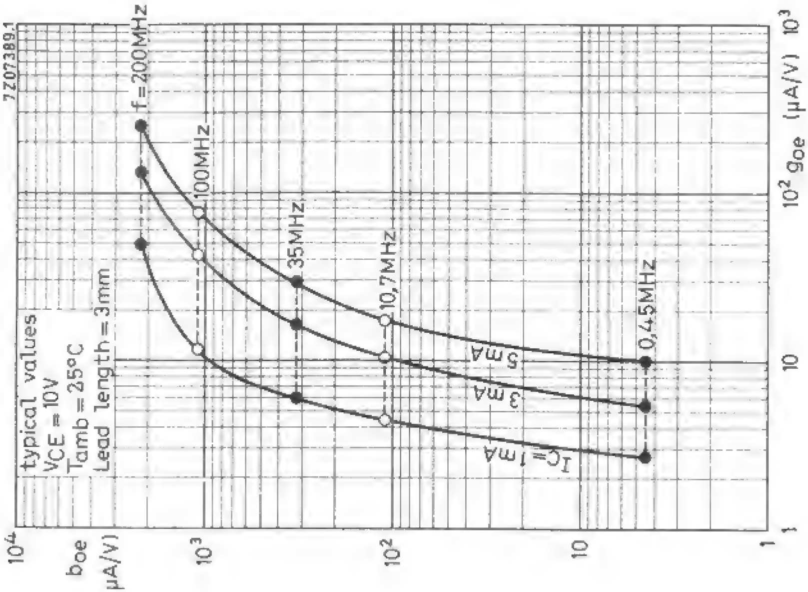
7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0
0,5
V_{BE} (V)
1
min
typ
max

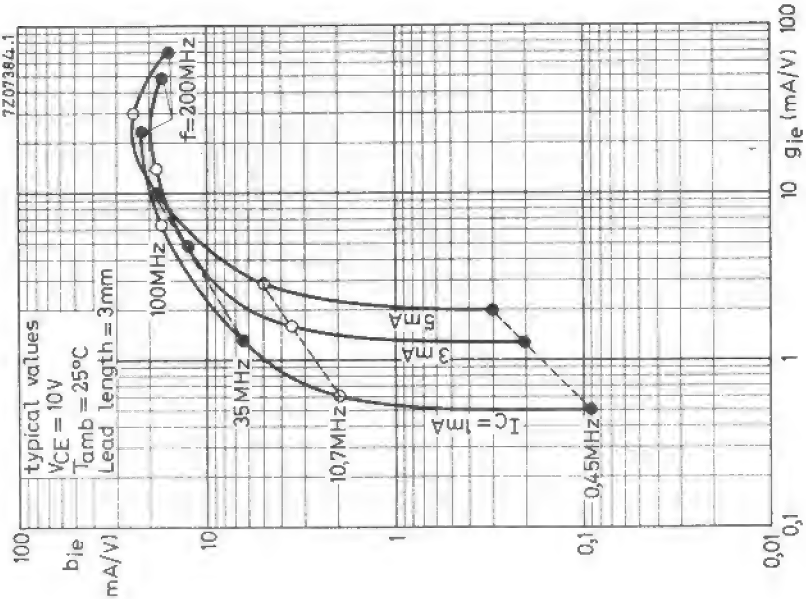


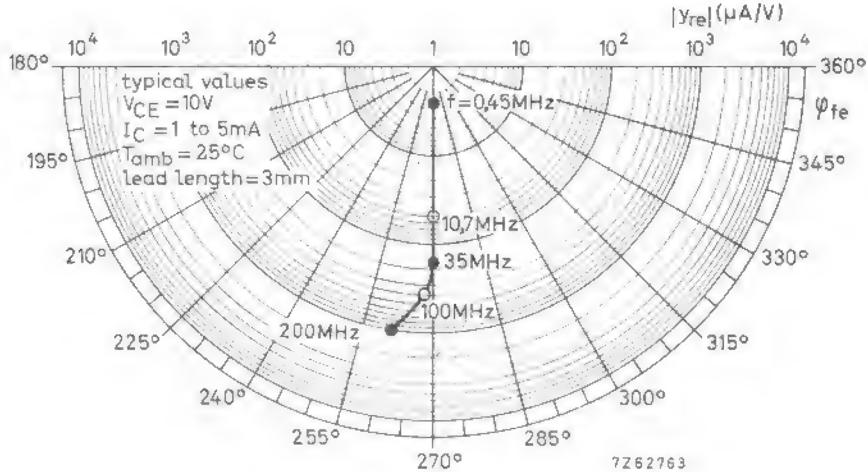
7Z07392
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
1
10
100
I_B (μA)
1000
min
typ
max


7Z07391
$V_{CE} = 10\ V$
$T_j = 25\ °C$
h_{FE}
150
100
50
0
typ
0,01
0,1
1
10
I_C (mA)
100

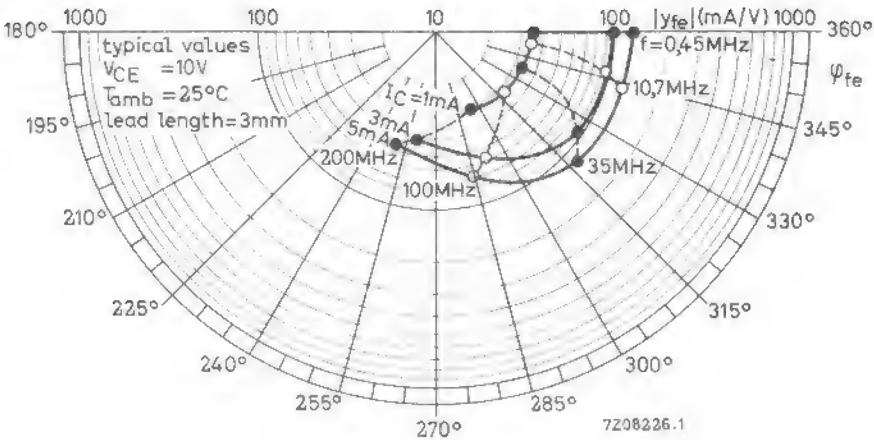

7Z07390.1
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
F (dB)
$-B_S$ (mA/V)
G_S (mA/V)
6
30
4
20
2
10
0
0
$I_C = 1\ mA$
$V_{CE} = 10\ V$
$T_j = 25\ °C$
typ
opt
opt
G_S
$-B_S$
0,1
1
10
100
f (MHz)
1000


7Z07389.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
boe (μA/V)
g_{oe} (μA/V)
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA

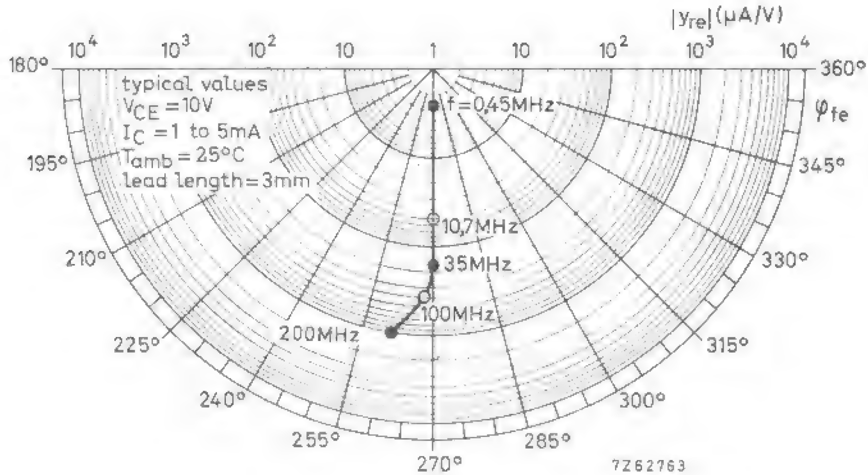

7Z07384.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
b_{ie} (mA/V)
g_{ie} (mA/V)
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA



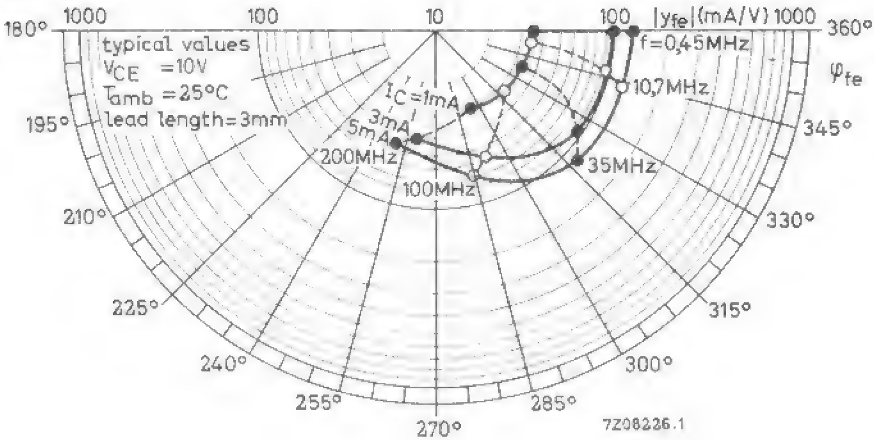
|y_re| (μA/V)
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4
180°
360°
φ_fe
typical values
V_CE = 10V
I_C = 1 to 5mA
T_amb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z62763



1000
100
10
100
|y_fe| (mA/V)
1000
180°
360°
φ_fe
typical values
V_CE = 10V
T_amb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
I_C = 1mA
3mA
5mA
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08226.1



|yre| (μA/V)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 360°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345°
7Z62763



1000 100 10 100 |yfe| (mA/V) 1000
180° 360°
φfe
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
IC = 1mA
3mA
5mA
195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345°
7Z08226.1

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for v.h.f. applications, e.g. as gain controlled pre-amplifier in v.h.f. television and f.m. tuners.

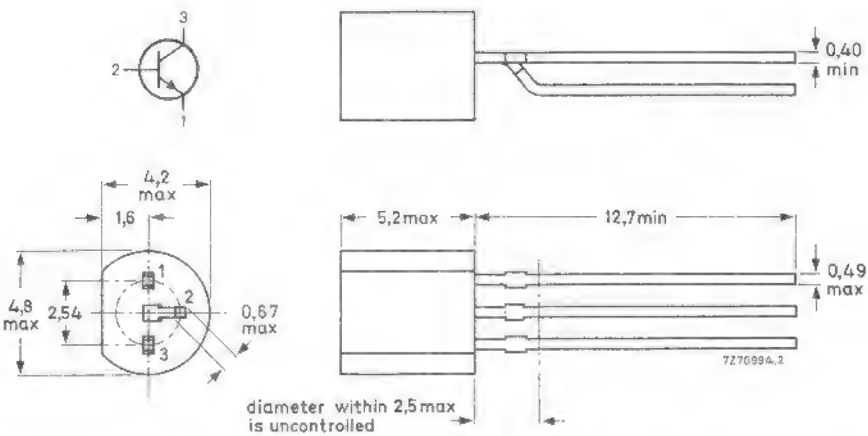
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	20	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
Transition frequency $-I_E$ = 2 mA; V_{CB} = 10 V	f_T	typ.	550	MHz
Maximum unilateral power gain $-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	34	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	27	dB
Noise figure at optimum source admittance $-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2,7	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector-emitter voltage ($R_{BE} \leqslant 1\ k\Omega$)	V_{CER}	max.	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V
Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	20	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ.	50	μA
		<	150	μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2,2	mA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0,84	V
$-I_E$ = 12 mA; V_{CB} = 7 V	$-V_{EB}$	<	1,0	V
Transition frequency				
$-I_E$ = 2 mA; V_{CB} = 10 V	f_T	typ.	550	MHz
$-I_E$ = 4 mA; V_{CB} = 5 V	f_T	<	530	MHz
Feedback capacitance at f = 10,7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	−0,8	pF
		<	1,0	pF
Noise figure at optimum source admittance				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	F	typ.	1,9	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2,5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2,0	dB

Maximum unilateral power gain (common base)

$$G_{UM}\ (\text{in dB}) = 10 \log \frac{|Y_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	34	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	27	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	G_{UM}	typ.	30	dB

y-parameters at f = 100 MHz (common base)
I_C = 2 mA; V_{CE} = 10 V

Input conductance	g_{ib}	typ.	66 mA/V
Input susceptance	$-b_{ib}$	typ.	15 mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	190 mA/V
Phase angle of feedback admittance	φ_{rb}	typ.	280°
Transfer admittance	$\|y_{fb}\|$	typ.	66 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	155°
Output conductance	g_{ob}	typ.	15 µA/V
Output susceptance	b_{ob}	typ.	660 µA/V

y-parameters at f = 50 MHz (common base)
$-I_E$ = 3 mA; V_{CB} = 10 V

Input conductance	g_{ib}	typ.	9,5 mA/V
Input susceptance	$-b_{ib}$	typ.	12 mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	100 µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	270°
Transfer admittance	$\|y_{fb}\|$	typ.	95 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	160°
Output conductance	g_{ob}	typ.	10 µA/V
Output susceptance	b_{ob}	typ.	350 µA/V

y-parameters at f = 200 MHz (common base)
$-I_E$ = 3 mA; V_{CB} = 10 V

Input conductance	g_{ib}	typ.	70 mA/V
Input susceptance	$-b_{ib}$	typ.	46 mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	340 µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	275°
Transfer admittance	$\|y_{fb}\|$	typ.	85 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	130°
Output conductance	g_{ob}	typ.	75 µA/V
Output susceptance	b_{ob}	typ.	1,3 mA/V

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for use as preamplifier, mixer and oscillator in v.h.f. and u.h.f. tuners.

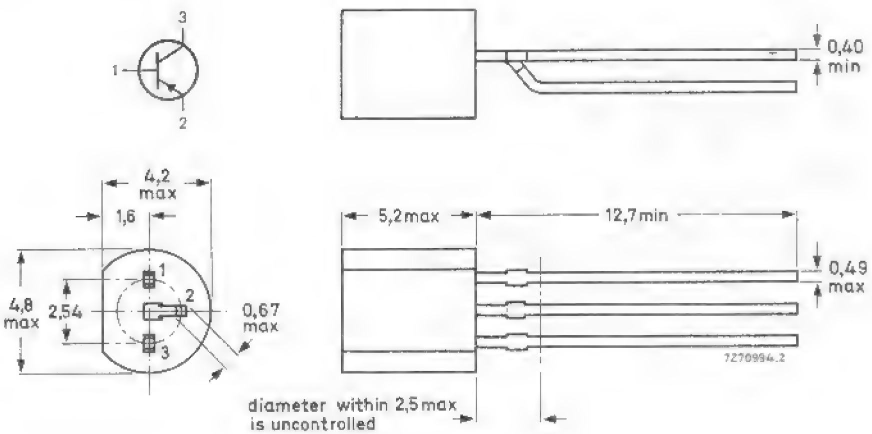
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350	MHz
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	F	<	6	dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 V	G_{tr}	>	14	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250 mW
Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current I_E = 0; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	50 nA
Base current I_E = 1 mA; $-V_{CB}$ = 10 V	$-I_B$	<	33 μA
Collector-base breakdown voltage open emitter; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage open base; $-I_C$ = 2 mA	$-V_{(BR)CEO}$	>	20 V
Emitter-base breakdown voltage open collector; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	4 V
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350 MHz
I_E = 5 mA; $-V_{CB}$ = 10 V	f_T	typ.	500 MHz 400 to 700 MHz
Feedback capacitance at f = 1 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	C_{re}	typ.	0,5 pF
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	F	typ. <	5 dB 6 dB
Transducer gain (common base) at f = 200 MHz I_E = 3 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 920 Ω	G_{tr}	> typ.	14 dB 17,5 dB

SILICON PLANAR TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for use in h.f. amplifiers and also in mixer and oscillator stages in v.h.f. and u.h.f. television receivers.

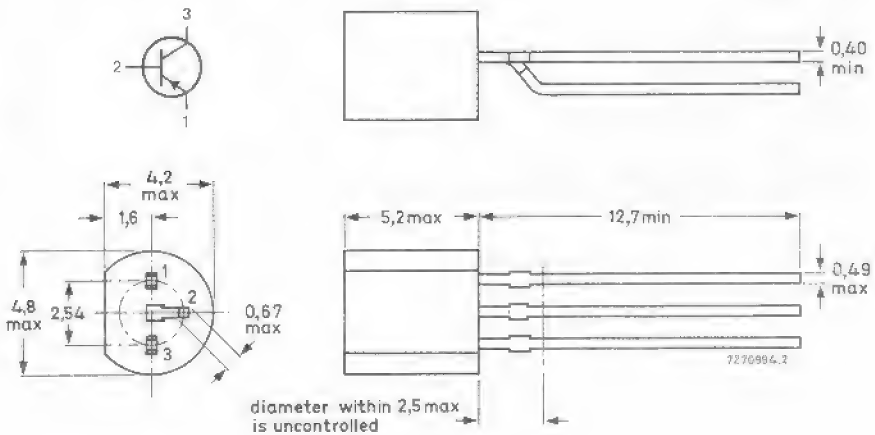
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_E = 1 mA; $-V_{CB}$ = 10 V	h_{FE}	>	25	
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350	MHz
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	F	<	6	dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 200 MHz	G_{tr}	>	14	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250 mW
→ Storage temperature	T_{stg}		−65 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	50 nA
Base current I_E = 1 mA; $-V_{CB}$ = 10 V	$-I_B$	<	38 μA
Collector-base breakdown voltage open emitter; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage open base; $-I_C$ = 2 mA	$-V_{(BR)CEO}$	>	20 V
Emitter-base breakdown voltage open collector; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	4 V
D.C. current gain I_E = 1 mA; $-V_{CB}$ = 10 V	h_{FE}	>	25
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350 MHz
Feedback capacitance at f = 1 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	C_{re}	typ.	0,9 pF
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V; R_S = 50 Ω	F	typ. <	5 dB 6 dB
Transducer gain (common base) at f = 200 MHz I_E = 3 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 920 Ω	G_{tr}	> typ.	14 dB 17,5 dB

SILICON PLANAR TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for application as a gain controlled preamplifier in v.h.f. tuners.

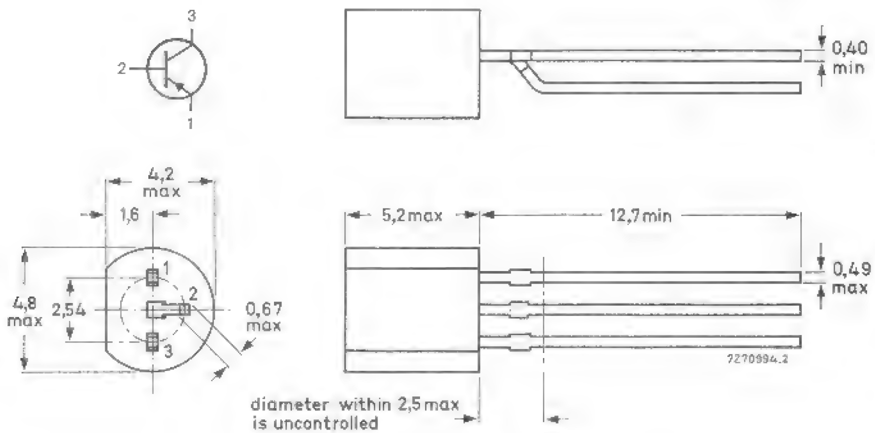
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	225 mW
Junction temperature	T_j	max.	150 °C
Transition frequency at f = 100 MHz I_E = 2 mA; $-V_{CB}$ = 10 V	f_T	typ.	750 MHz
Noise figure at f = 200 MHz I_E = 2 mA; $-V_{CB}$ = 10 V R_S = 60 Ω; R_L = 1 kΩ	F	typ.	2,5 dB
Transducer gain (common base) I_E = 2 mA; $-V_{CB}$ = 10 V; f = 200 MHz R_S = 60 Ω; R_L = 1 kΩ	G_{tr}	typ.	16 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	225 mW
→ Storage temperature	T_{stg}		−65 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0; -V_{CB} = 15$ V	$-I_{CBO}$	<	100 nA
Emitter cut-off current $I_C = 0; -V_{EB} = 1$ V	$-I_{EBO}$	<	100 nA
Base current $I_E = 2$ mA; $-V_{CB} = 10$ V	$-I_B$	typ. <	55 µA 125 µA
$-I_C = 9$ mA; $-V_{CE} = 4$ V	$-I_B$	<	3,6 mA
Collector-base breakdown voltage open emitter; $-I_C = 10$ µA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage open base; $-I_C = 1$ mA	$-V_{(BR)CEO}$	>	25 V
Emitter-base breakdown voltage open collector; $-I_E = 10$ µA	$-V_{(BR)EBO}$	>	3 V
Transition frequency at f = 100 MHz $I_E = 2{,}0$ mA; $-V_{CB} = 10$ V	f_T	typ.	750 MHz
$I_E = 6{,}5$ mA; $-V_{CB} = 5{,}5$ V	f_T	<	200 MHz
Feedback capacitance at f = 500 kHz $I_E = 0; -V_{CB} = 10$ V	C_{re}	typ.	0,7 pF
$I_E = 0; -V_{CB} = 10$ V	C_{rb}	typ. <	135 fF 160 fF
Noise figure at f = 200 MHz $I_E = 2$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 1\ k\Omega$	F	typ. <	2,5 dB 4 dB
Transducer gain (common base) at f = 200 MHz $I_E = 2$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 1\ k\Omega$	G_{tr}	typ.	16 dB

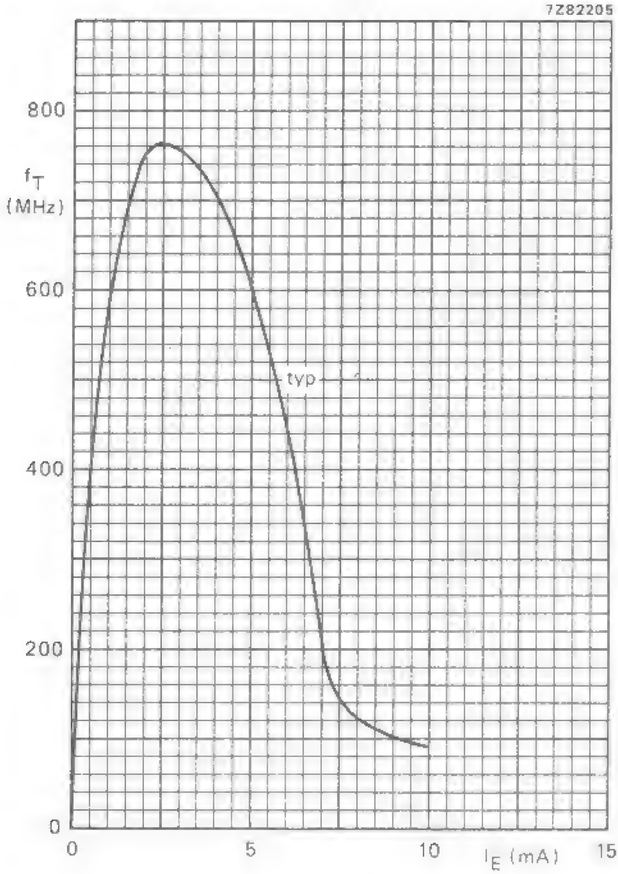


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 °C.

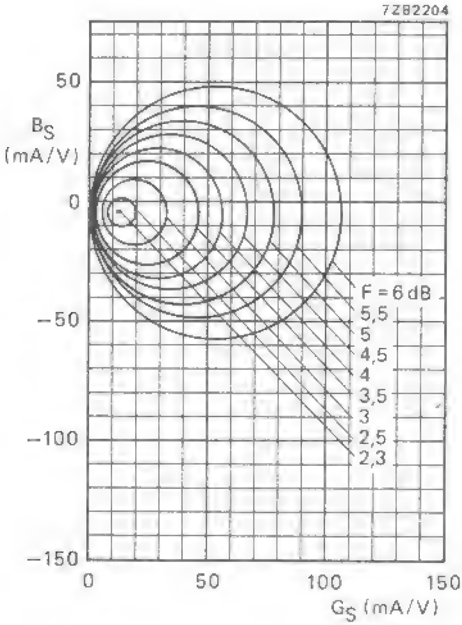


Fig. 3 Circles of constant noise figure.
$-V_{CB}$ = 10 V; I_E = 2 mA; f = 200 MHz;
T_{amb} = 25 °C; typical values.

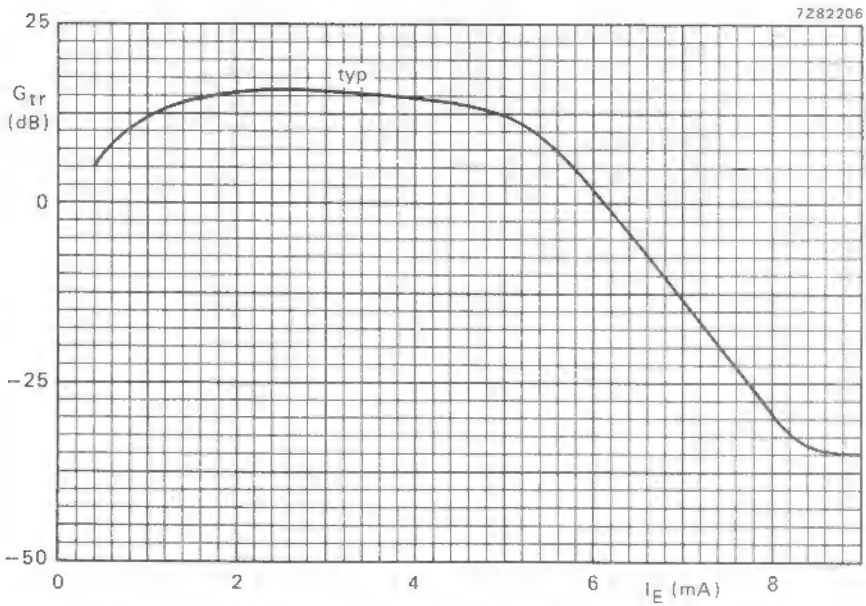


Fig. 4 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 920 Ω; R_S = 60 Ω; f = 200 MHz; T_{amb} = 25 °C.

SILICON PLANAR TRANSISTOR

P-N-P transistor in a plastic T-package, primarily intended for application as gain controlled preamplifier in u.h.f. television tuners.

QUICK REFERENCE DATA

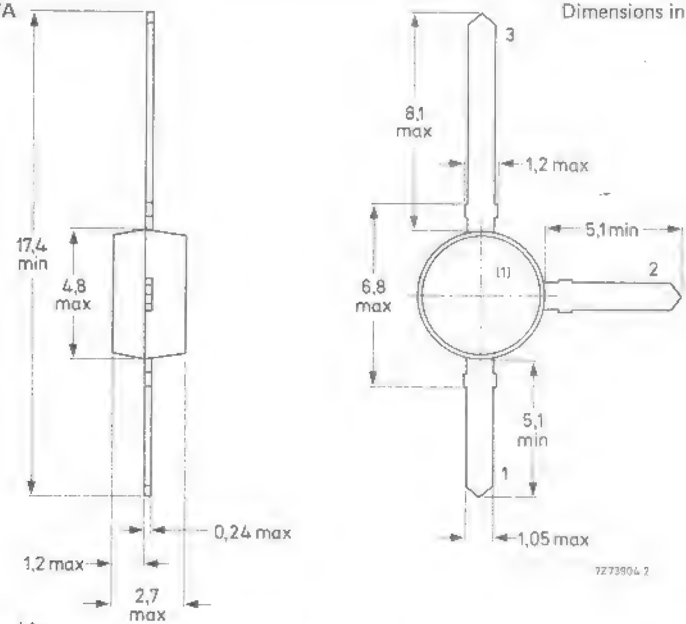
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160 mW
Junction temperature	T_j	max.	150 °C
Transition frequency at f = 100 MHz I_E = 3 mA; $-V_{CB}$ = 10 V	f_T	typ.	900 MHz
Noise figure (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	F	typ.	4 dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	G_{tr}	typ.	13 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections
1. Emitter
2. Base
3. Collector



(1) = type number marking.

Products approved to CECC 50 002-127, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Base current (d.c.)	$-I_B$	max.	5 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160 mW
Storage temperature	T_{stg}		−55 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	600 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB} = 15$ V	$-I_{CBO}$	<	100 nA
Emitter cut-off current $I_C = 0$; $-V_{EB} = 1$ V	$-I_{EBO}$	<	100 nA
Collector-base breakdown voltage open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage open base; $-I_C = 1$ mA	$-V_{(BR)CEO}$	>	30 V
Emitter-base breakdown voltage open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	3 V
D.C. current gain $I_E = 3$ mA; $-V_{CE} = 10$ V	h_{FE}	> typ.	15 60
$I_E = 7$ mA; $-V_{CE} = 4$ V	h_{FE}	>	10
Transition frequency at f = 100 MHz $I_E = 3$ mA; $-V_{CB} = 10$ V	f_T	typ. 700 to	900 MHz 1100 MHz
$I_E = 7$ mA; $-V_{CB} = 5$ V	f_T	<	200 MHz
Feedback capacitance at f = 500 kHz $I_E = 1$ mA; $-V_{CB} = 10$ V	C_{re}	typ.	0,45 pF
$I_E = 0$; $-V_{CB} = 10$ V	C_{rb}	typ. <	115 fF 140 fF
Noise figure (common base) $I_E = 3$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	F	typ. <	4 dB 5 dB
Transducer gain (common base) $I_E = 3$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	G_{tr}	> typ.	11 dB 13 dB

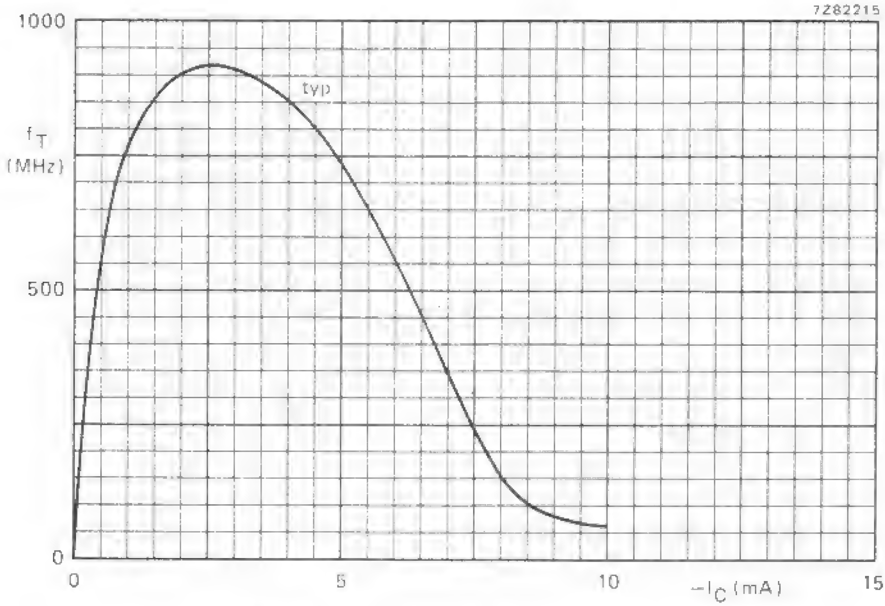


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 °C.

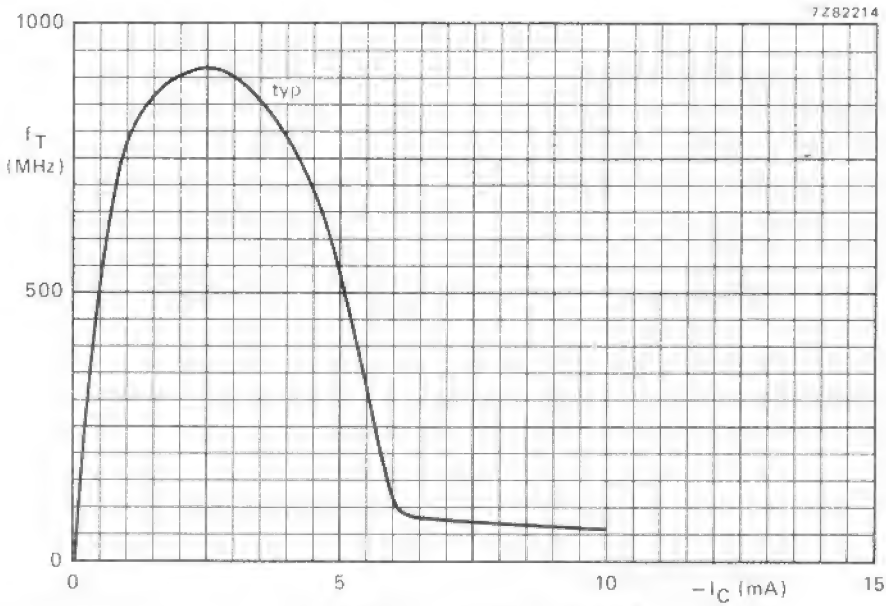


Fig. 3 $-V_{CC}$ = 12 V; R_C = 1 kΩ; f = 100 MHz; T_{amb} = 25 °C.

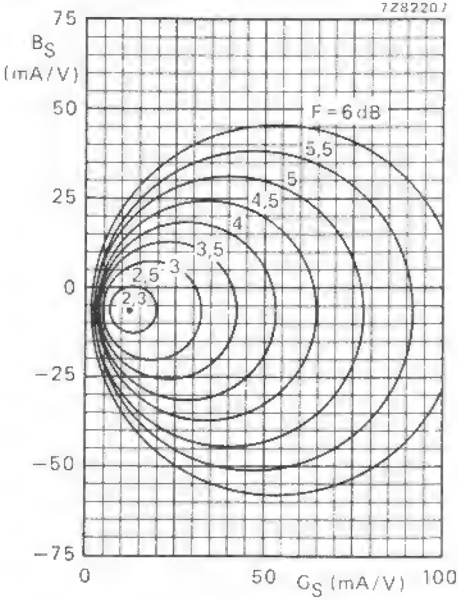


Fig. 4 Circles of constant noise figure.

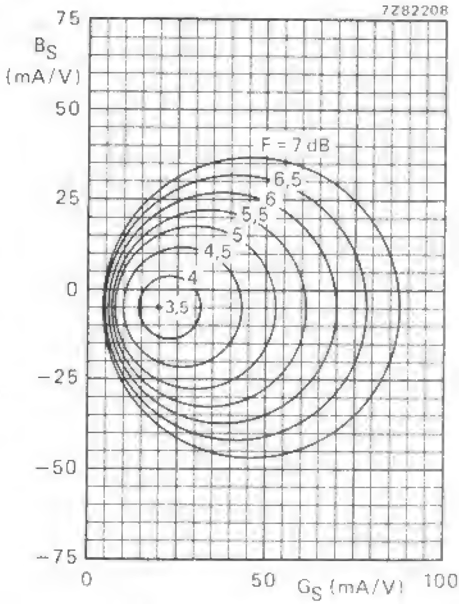
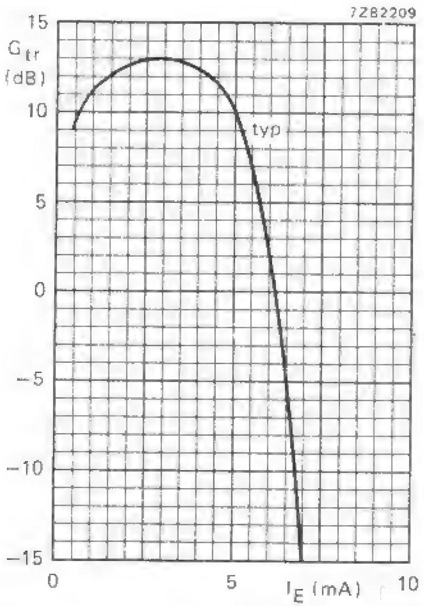


Fig. 5 Circles of constant noise figure.



Measuring conditions:

Fig. 4 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 200 MHz; T_{amb} = 25 °C; typical values.

Fig. 5 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 800 MHz; T_{amb} = 25 °C; typical values.

Fig. 6 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 500 Ω; f = 800 MHz; T_{amb} = 25 °C.

Conditions for Figs 7 to 10: I_E = 3 mA; $-V_{CB}$ = 10 V; T_{amb} = 25 °C; typical values.

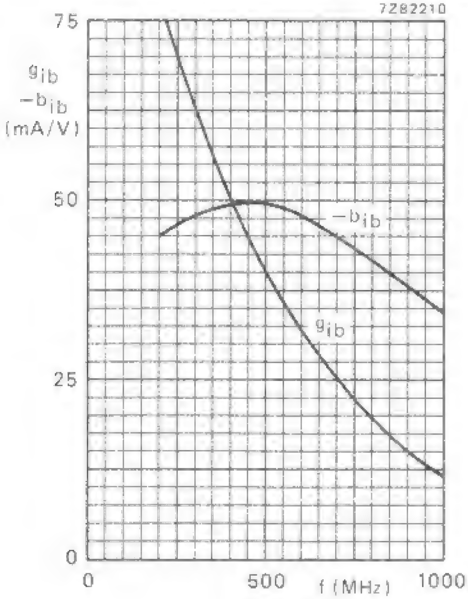


Fig. 7.

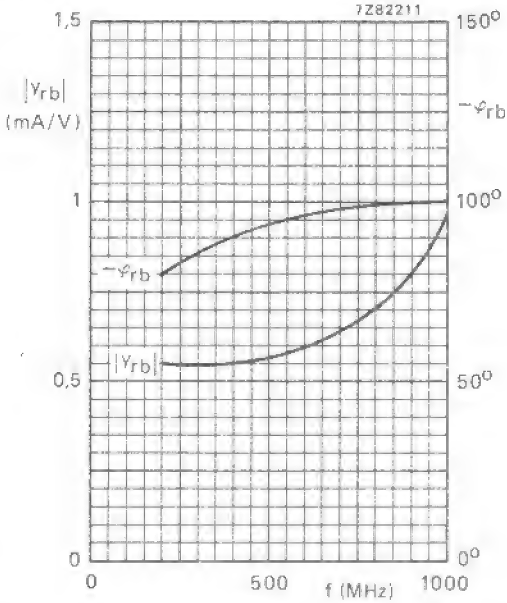


Fig. 8.

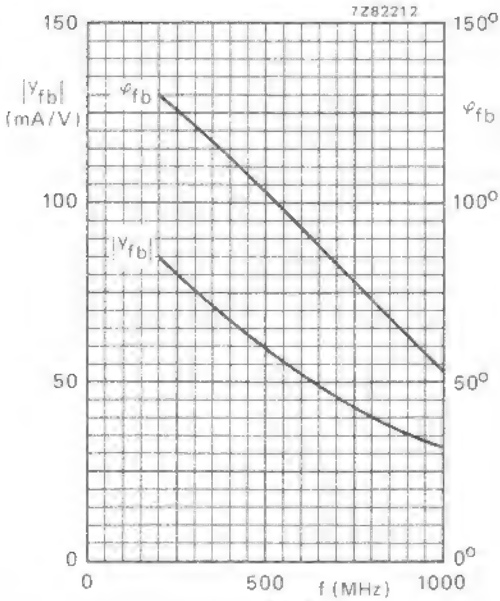


Fig. 9.

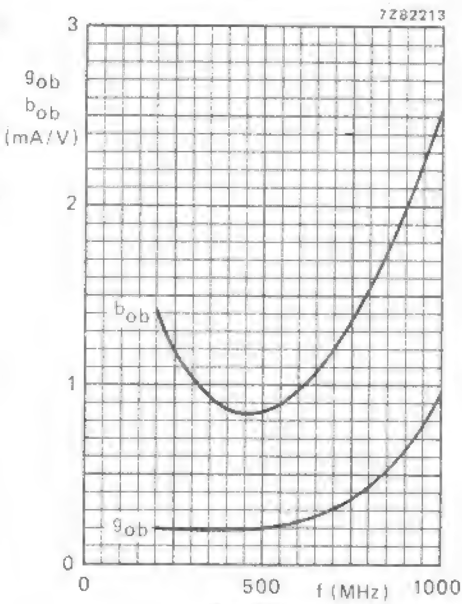


Fig. 10.

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic T-package intended for application as self-oscillating mixer stage in u.h.f. tuners.

QUICK REFERENCE DATA

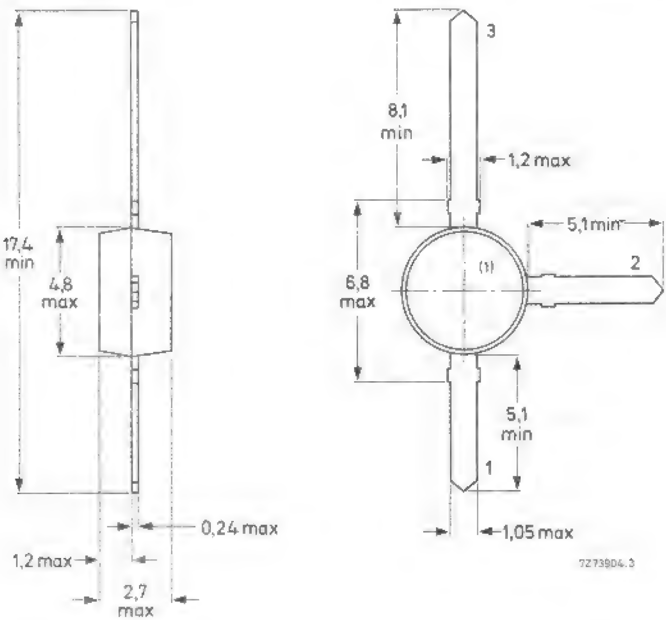
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35	V
Collector current (d.c.)	$-I_C$	max.	30	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 3 mA; $-V_{CB}$ = 10 V	f_T	typ.	900	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections
1. Emitter
2. Base
3. Collector



(1) = type number marking.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3	V
Collector current (d.c.)	$-I_C$	max.	30	mA
Emitter current (d.c.)	I_E	max.	35	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160	mW
Storage temperature	T_{stg}		−55 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	600	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	100	nA
Emitter cut-off current $I_C = 0$; $-V_{EB}$ = 1 V	$-I_{EBO}$	<	100	nA
D.C. current gain $-I_C$ = 3 mA; $-V_{CB}$ = 10 V	h_{FE}	> typ.	25 50	
Transition frequency at f = 100 MHz I_E = 3 mA; $-V_{CB}$ = 10 V	f_T	typ.	900 750 to 1060	MHz MHz
I_E = 7 mA; $-V_{CB}$ = 5 V	f_T	> typ.	400 700	MHz MHz
Feedback capacitance at f = 1 MHz $I_E = 0$; $-V_{CB}$ = 10 V	C_{rb}	typ. <	110 140	fF fF
I_E = 1 mA; $-V_{CB}$ = 5 V	C_{re}	typ.	475	fF
Noise figure at R_S = 60 Ω I_E = 3 mA; $-V_{CB}$ = 10 V; f = 200 MHz	F	typ.	2,6	dB
I_E = 3 mA; $-V_{CB}$ = 10 V; f = 800 MHz	F	typ. <	4,7 6,0	dB dB
Transducer gain (common base) at f = 800 MHz I_E = 3 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 500 Ω	G_{tr}	> typ.	13,0 14,5	dB dB

SILICON PLANAR TRANSISTOR

P-N-P transistor in a subminiature plastic T-package, primarily intended for application in r.f. stages in u.h.f. tuners using p-i-n diode attenuators.

QUICK REFERENCE DATA

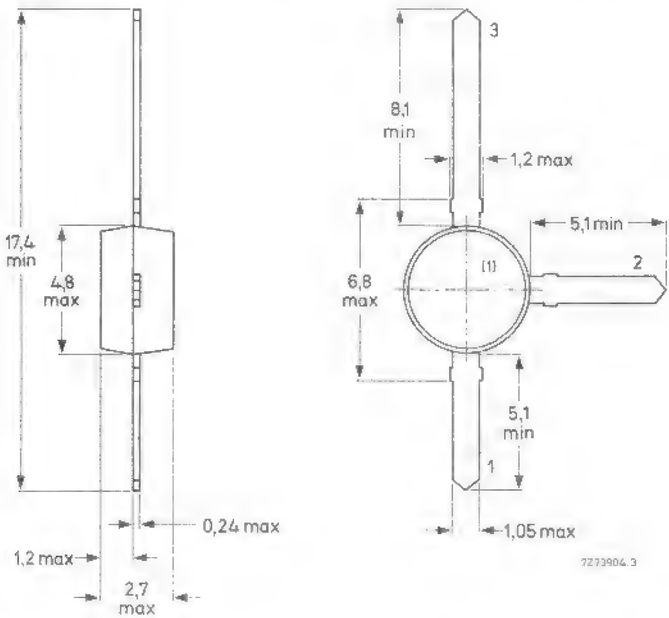
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	30	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	140	mW
Junction temperature	T_j	max.	125	°C
Transition frequency at f = 100 MHz I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	typ.	1350	MHz
Noise figure (common base) I_E = 10 mA; $-V_{CB}$ =10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	F	typ.	4,5	dB
Transducer gain (common base) I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	G_{tr}	typ.	16	dB

MECHANICAL DATA

Fig. 1 SOT-37.

Connections

1. Emitter
2. Base
3. Collector



(1) = type number marking.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (peak value)	$-I_{CM}$	max.	30 mA
Base current (d.c.)	$-I_B$	max.	10 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	140 mW
Storage temperature	T_{stg}		−55 to +125 °C
Junction temperature	T_j	max.	125 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	500 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current			
$I_E = 0$; $-V_{CB}$ = 15 V	$-I_{CBO}$	<	100 nA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 1 V	$-I_{EBO}$	<	100 nA
Collector-base breakdown voltage			
open emitter; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	20 V
Collector-emitter breakdown voltage			
open base; $-I_C$ = 1 mA	$-V_{(BR)CEO}$	>	20 V
Emitter-base breakdown voltage			
open collector; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	3 V
D.C. current gain			
I_E = 2 mA; $-V_{CB}$ = 10 V	h_{FE}	>	15
I_E = 10 mA; $-V_{CB}$ = 10 V	h_{FE}	>	20
Transition frequency at f = 100 MHz			
I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	typ.	1350 MHz
I_E = 15 mA; $-V_{CB}$ = 5 V	f_T	typ.	1000 MHz
Feedback capacitance at f = 500 kHz			
$I_E = 0$; $-V_{CB}$ = 10 V	C_{re}	typ.	0,65 pF
$I_E = 0$; $-V_{CB}$ = 10 V	C_{rb}	typ.	120 fF
Noise figure (common base)			
I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	F	typ. <	4,5 dB 6,0 dB
Transducer gain (common base)			
I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	G_{tr}	typ.	16 dB

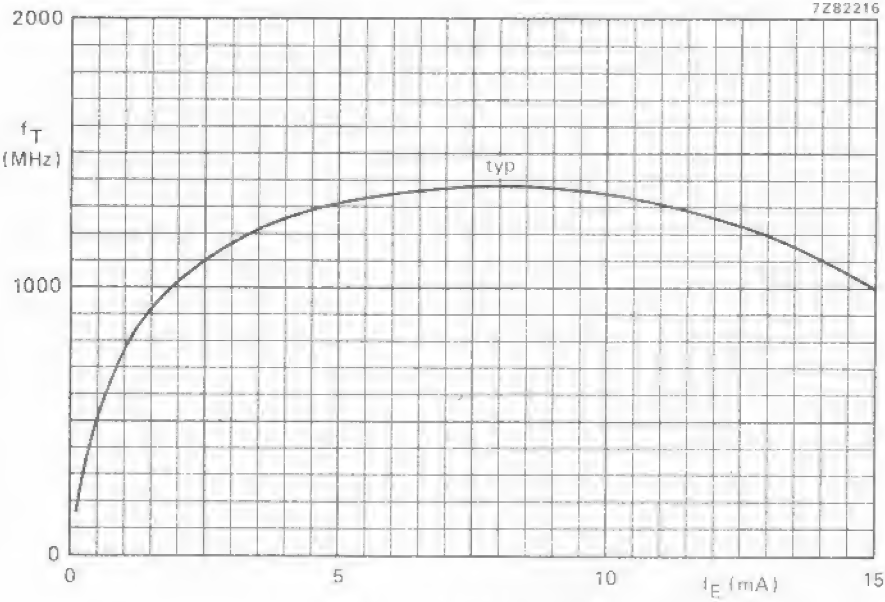


Fig. 2 $-V_{CB}$ = 10 V; T_j = 25 °C.

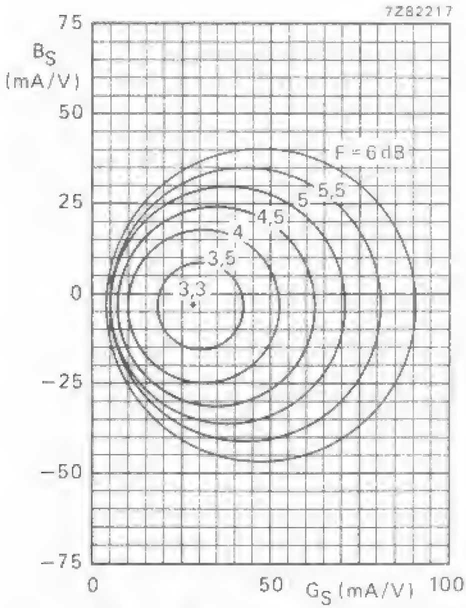


Fig. 3 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 200 MHz; T_{amb} = 25 °C; typical values.

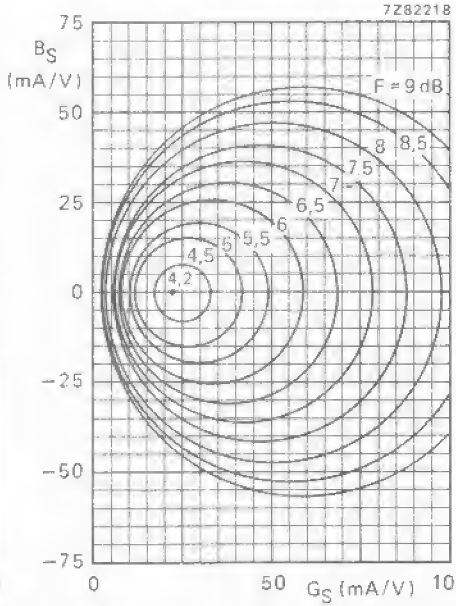


Fig. 4 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz; T_{amb} = 25 °C; typical values.

Conditions for Figs 5 to 8: I_E = 10 mA; ——— $-V_{CB}$ = 10 V; – – – $-V_{CB}$ = 5 V; T_{amb} = 25 °C; typical values.

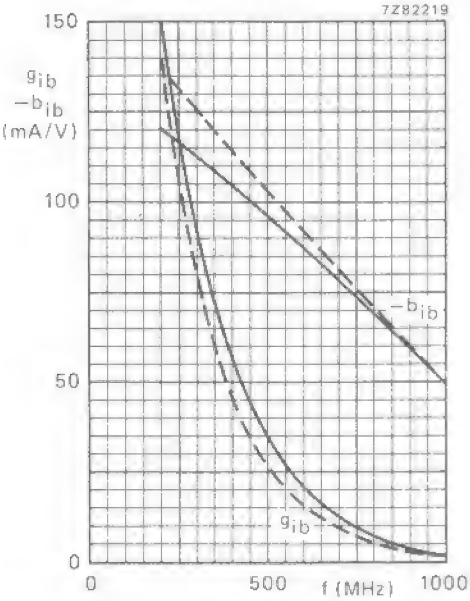


Fig. 5.

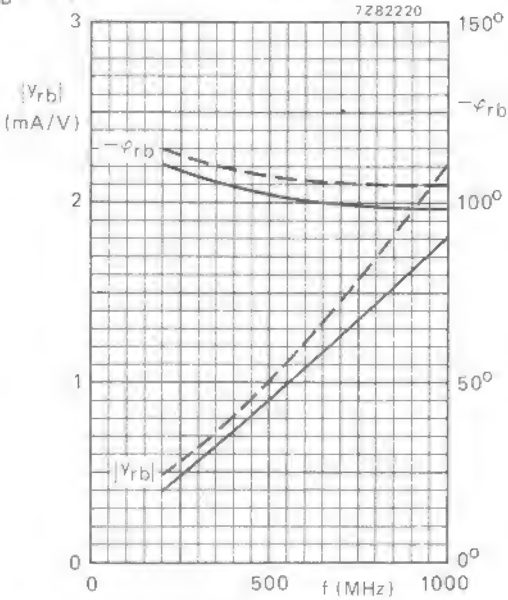


Fig. 6.

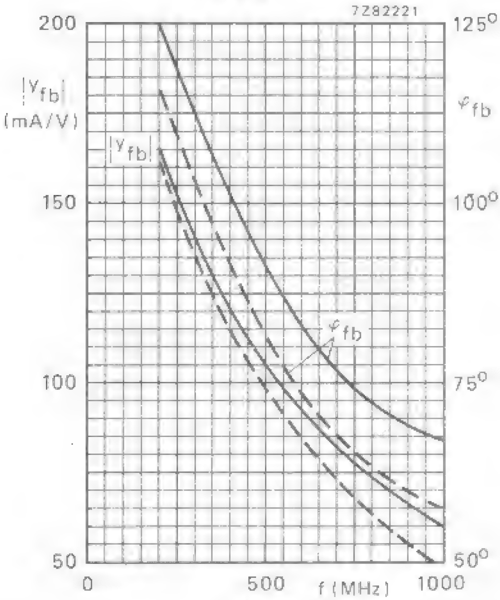


Fig. 7.

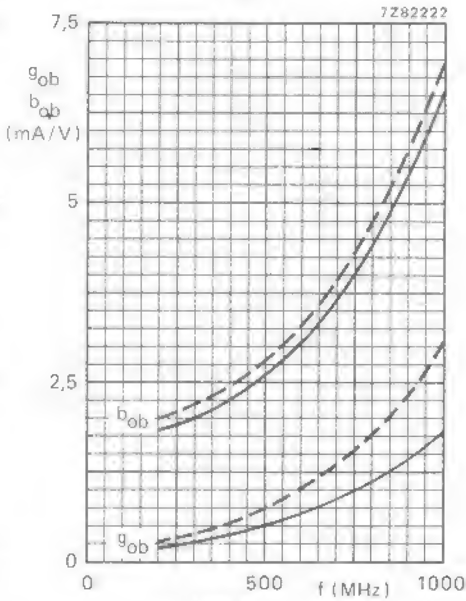


Fig. 8.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope primarily intended for use in active probes, frequency multipliers and linear amplifiers.

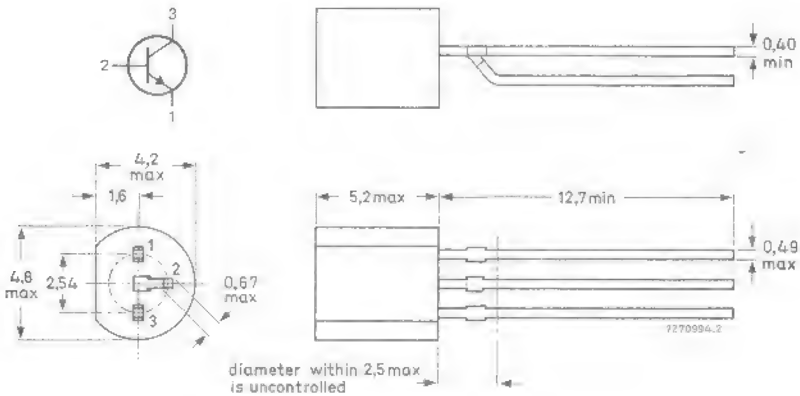
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
D.C. current I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40 V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40 V
Collector-emitter voltage (open base)	V_{CEO}	max.	15 V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5 V
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
Storage temperature	T_{stg}	−65 to + 150 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400 nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 125$ °C	I_{CBO}	<	30 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 2$ V	I_{EBO}	<	100 nA
Saturation voltage			
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0,25 V
	V_{BEsat}	0,70 to 0,85 V	
Knee voltage			
$I_C = 45$ mA; I_B = value for which $I_C = 50$ mA at $V_{CE} = 2$ V	V_{CEK}	<	0,8 V
D.C. current gain			
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	40
Transition frequency at f = 100 MHz			
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	500 MHz
$I_C = 40$ mA; $V_{CE} = 10$ V	f_T	>	490 MHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4 pF
Emitter capacitance at f = 1 MHz			
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4,5 pF

Maximum unilateral power gain (y_{re} assumed to be zero)

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

$I_C = 10$ mA; $V_{CE} = 10$ V; f = 200 MHz	G_{UM}	typ.	19 dB

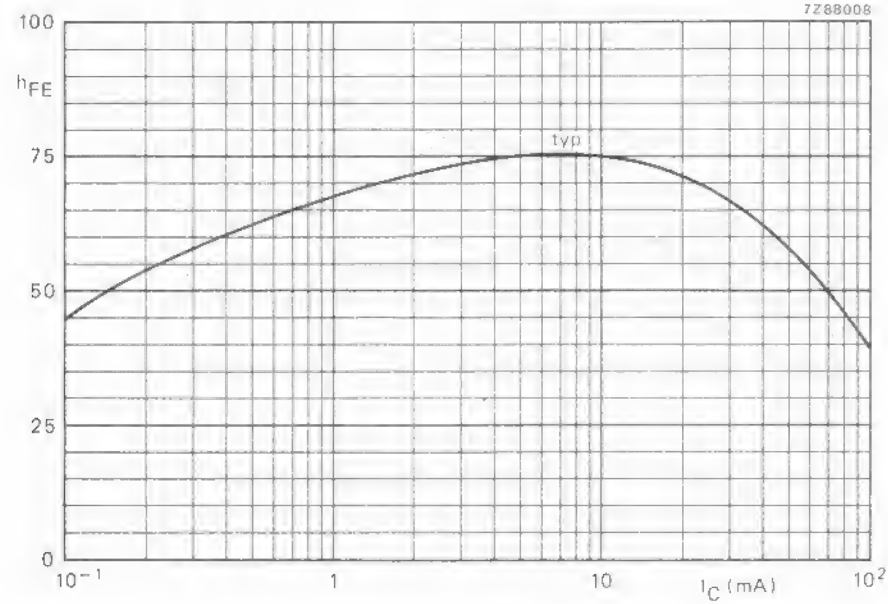


Fig. 2 $V_{CE} = 1$ V; $T_j = 25$ °C.

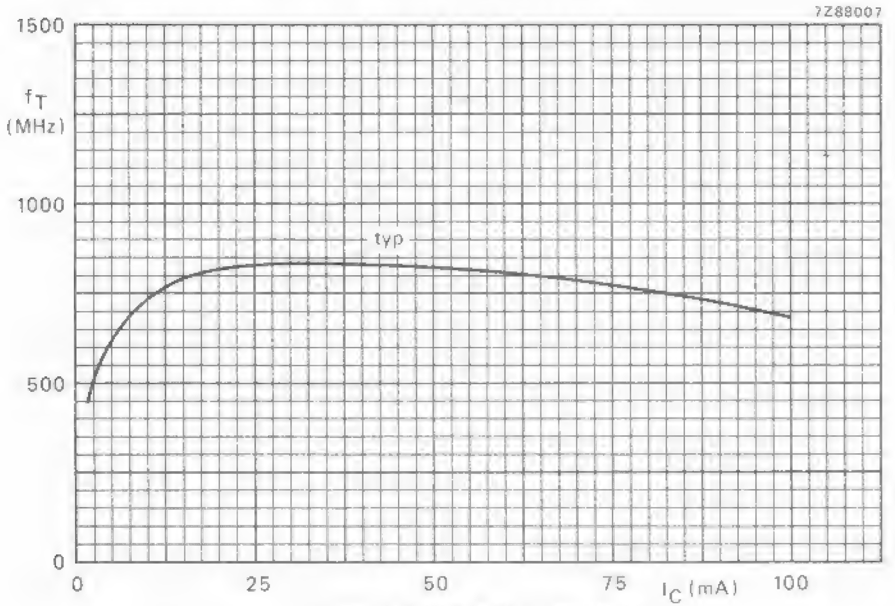


Fig. 3 $V_{CE} = 10$ V; $T_j = 25$ °C.

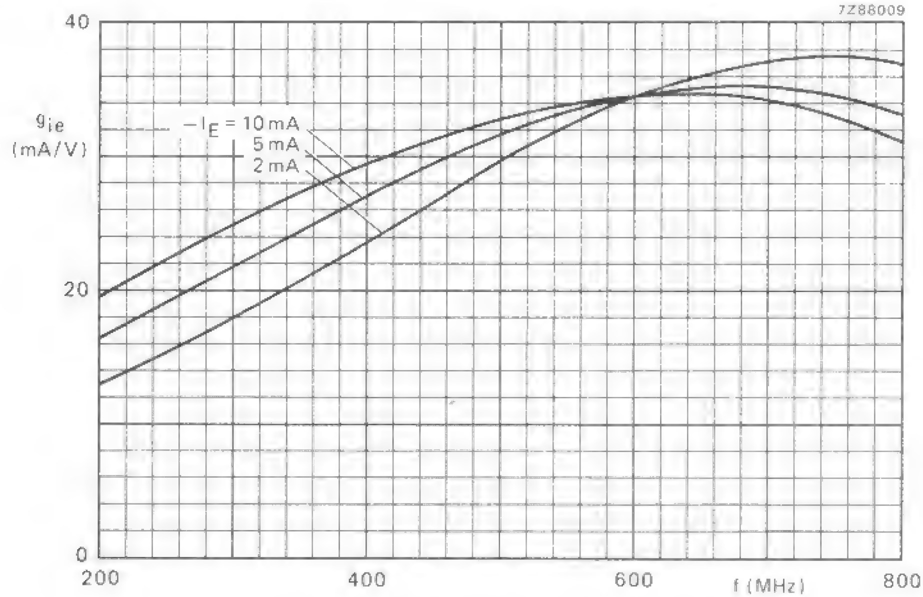


Fig. 4 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

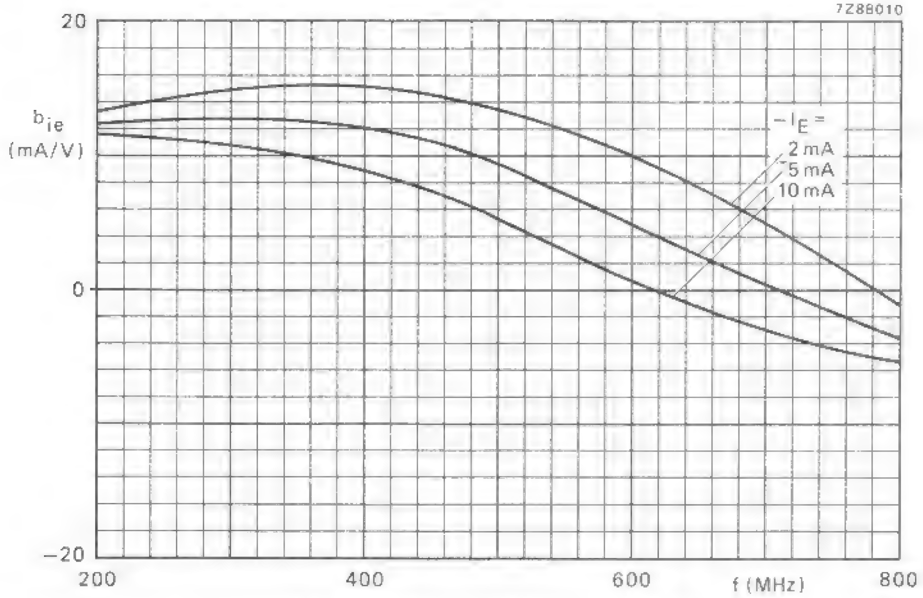


Fig. 5 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

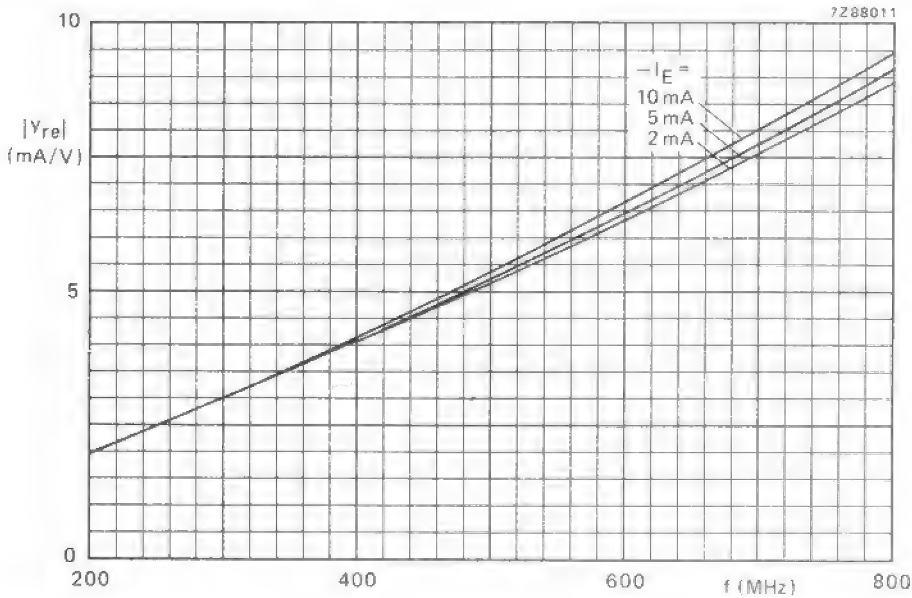


Fig. 6 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

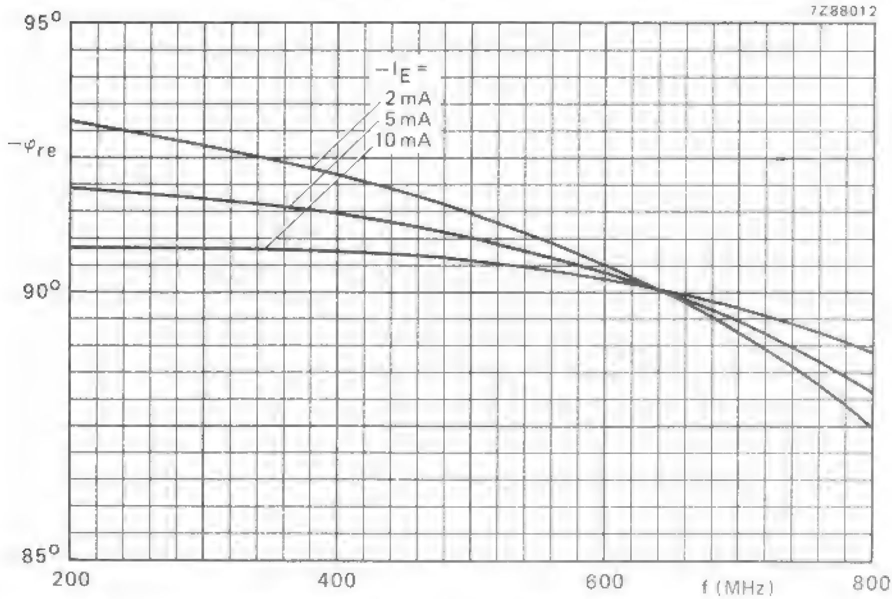


Fig. 7 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

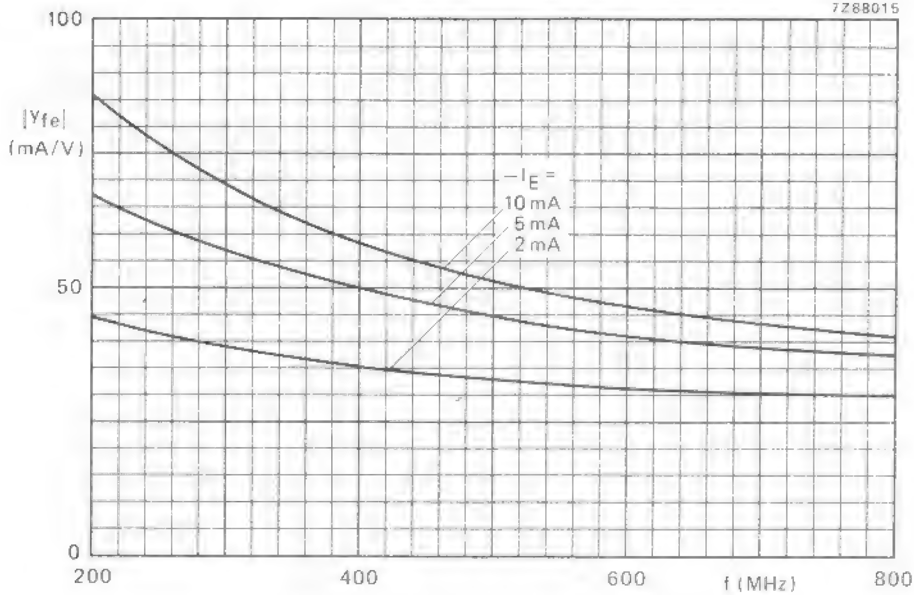


Fig. 8 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

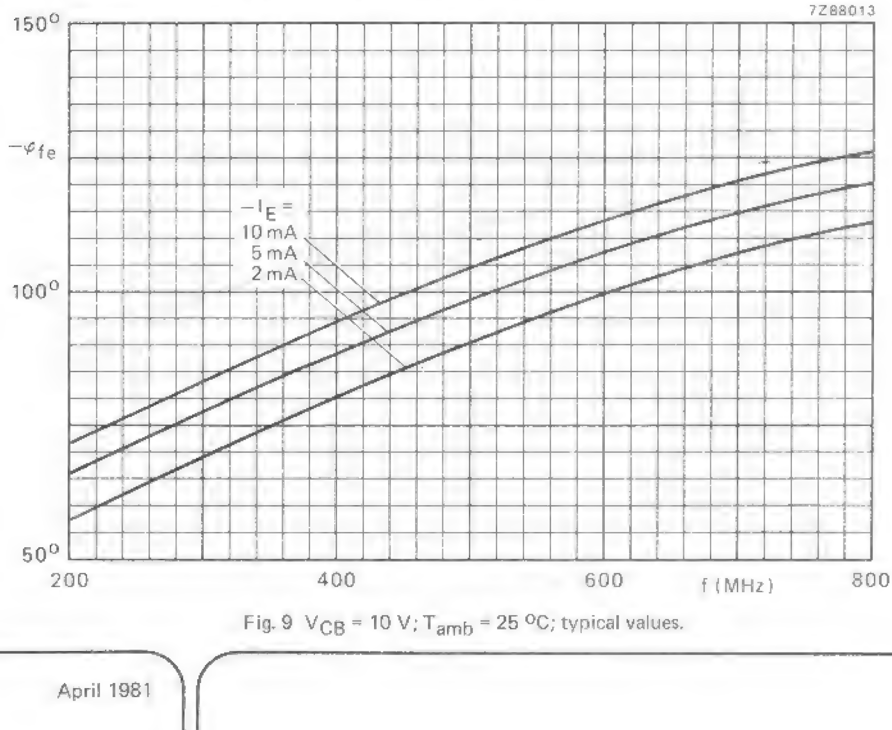


Fig. 9 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

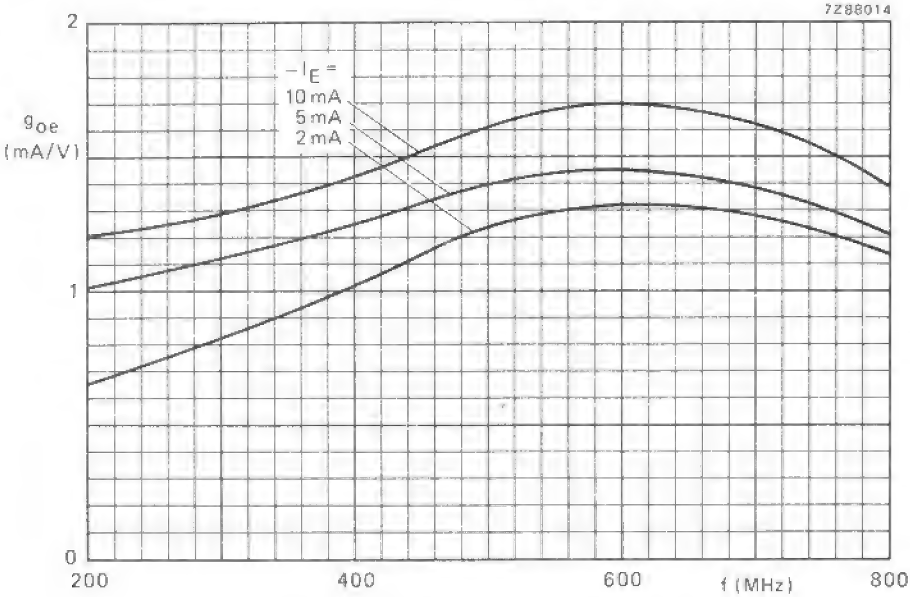


Fig. 10 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

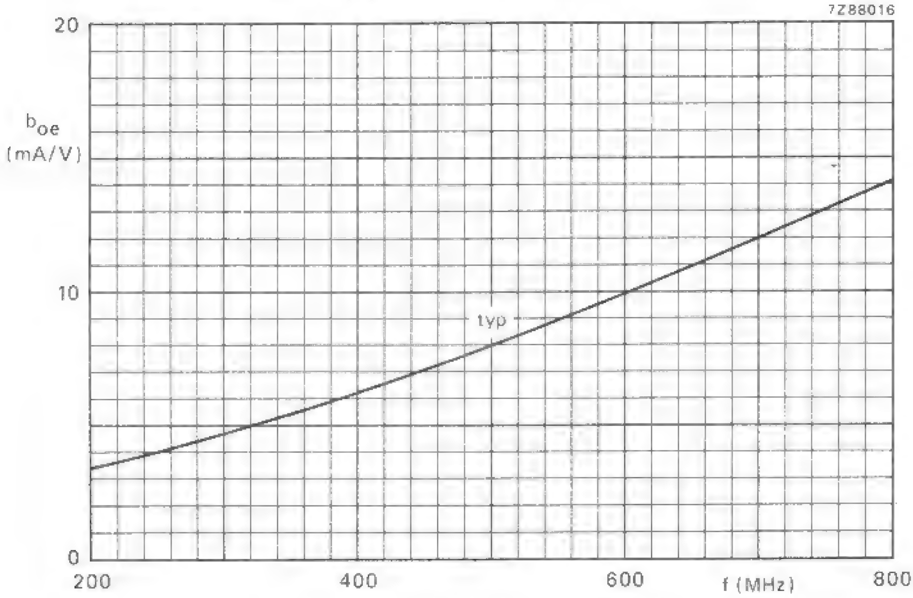


Fig. 11 V_{CB} = 10 V; $-I_E$ = 2 to 10 mA; T_{amb} = 25 °C

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Planar epitaxial transistors in TO-39 metal envelopes, intended as general purpose amplifiers and switching devices in industrial and telephone applications.

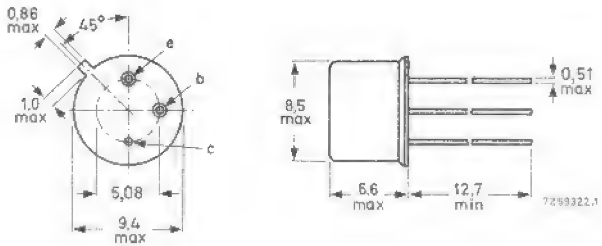
QUICK REFERENCE DATA

			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Collector current (d.c.)	$-I_C$	max.	0,5		A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}		50 to 150		
Transition frequency at f = 35 MHz $-I_C$ = 15 mA; $-V_{CE}$ = 10 V	f_T	typ.	70		MHz

MECHANICAL DATA Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



max. lead diameter is guaranteed only for 12,7 mm

Accessories: 56245 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

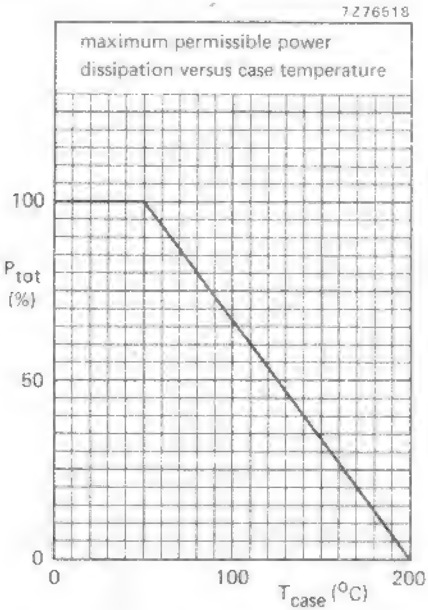
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.5	A

Power dissipation

Total power dissipation up to $T_{case} = 50\ ^oC$	P_{tot}	max.	5.0	W



Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$ =	200	°C/W
From junction to case	$R_{th\ j-c}$ =	30	°C/W

CHARACTERISTICS — $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 200$ V	$-I_{CBO}$	<	5	μA
$I_B = 0$; $-V_{CE} = 200$ V; $T_j = 125\ ^oC$	$-I_{CEO}$	<	300	μA

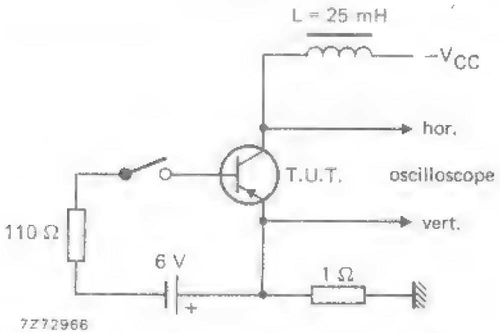
Emitter cut-off current

$I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	5	μA

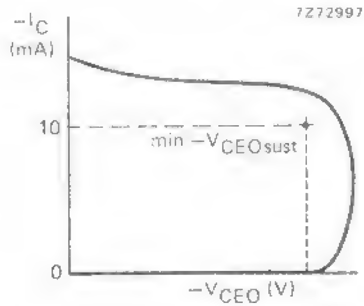
Collector-emitter sustaining voltage

			BFT44	BFT45	
$-I_C = 10$ mA; $I_B = 0$; L = 25 mH	$-V_{CEOsust}$	>	300	250	V 1)

Test circuit for $V_{CEOsust}$



Oscilloscope display for $V_{CEOsust}$



Saturation voltages

$-I_C = 10$ mA; $-I_B = 1$ mA		$-V_{CEsat}$	<	0,5	V
		$-V_{BEsat}$	<	0,8	V
$-I_C = 100$ mA; $-I_B = 10$ mA		$-V_{CEsat}$	<	1,4	V
		$-V_{BEsat}$	<	0,9	V
$-I_C = 500$ mA; $-I_B = 100$ mA	BFT44	$-V_{CEsat}$	<	5,0	V 2)
	BFT45	$-V_{CEsat}$	<	3,0	V 2)
		$-V_{BEsat}$	<	1,2	V 2)

D.C. current gain

$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}		50 to 150	
$-I_C = 100$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	2)

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB} = 20$ V	C_c	<	15	pF

1) $-V_{CC} = 0$ to 50 V; f = 400 Hz; δ = 0.5 (see also test circuit).
2) Measured under pulse conditions: $t_p = 300$ μs; δ ≤ 0,02.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 35 MHz

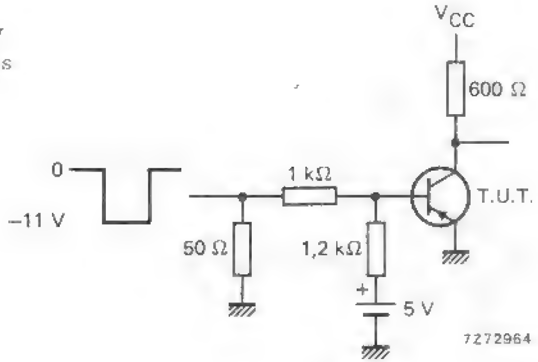
$-I_C$ = 15 mA; $-V_{CE}$ = 10 V	f_T	typ.	70	MHz

Switching times

$-I_{Con}$ = 50 mA; $-I_{Bon}$ = I_{Boff} = 5 mA (test circuit 1)	t_{on}	typ.	125	ns
	t_{off}	typ.	850	ns
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 100 mA (test circuit 2)	t_{on}	typ.	125	ns
	t_{off}	typ.	125	ns

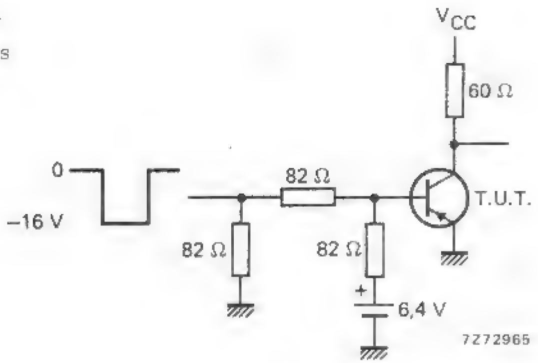
Test circuit 1

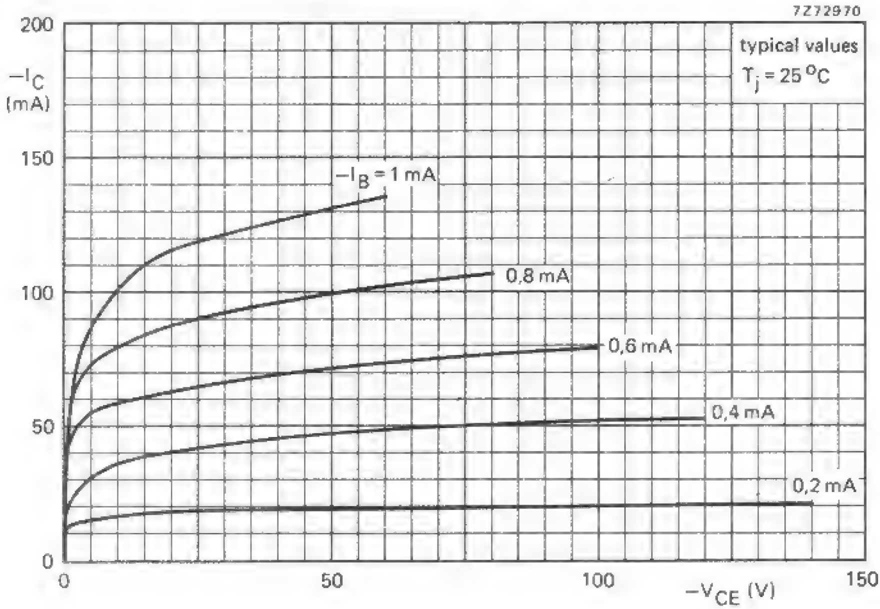
V_{CC} = −31 V
t_p = 10 μs

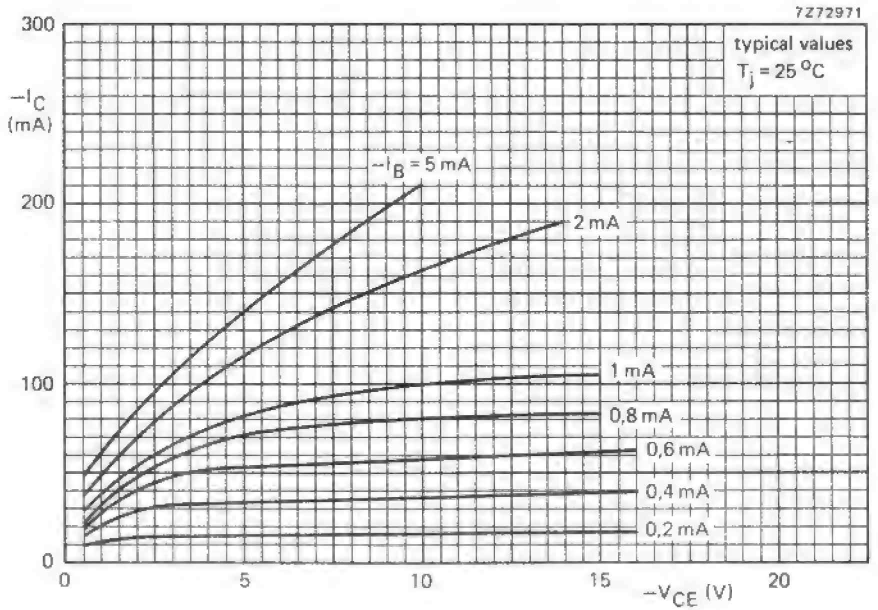


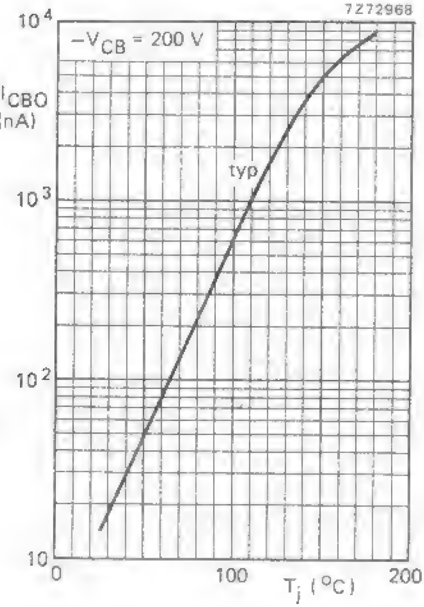
Test circuit 2

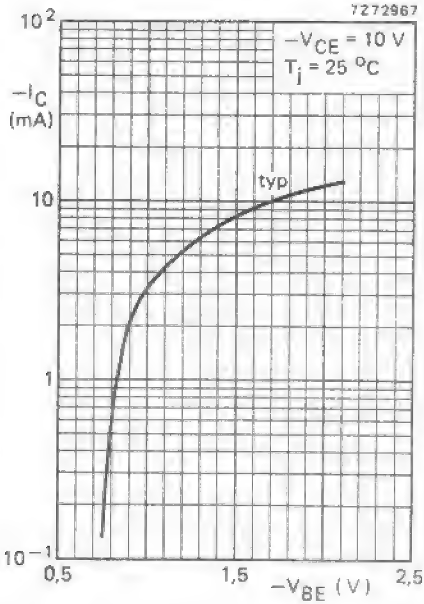
V_{CC} = −31 V
t_p = 10 μs

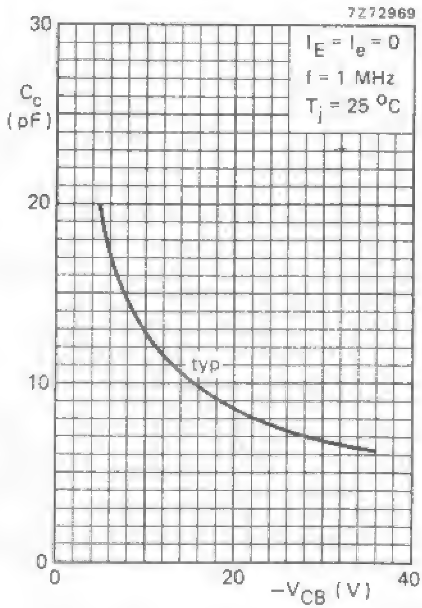


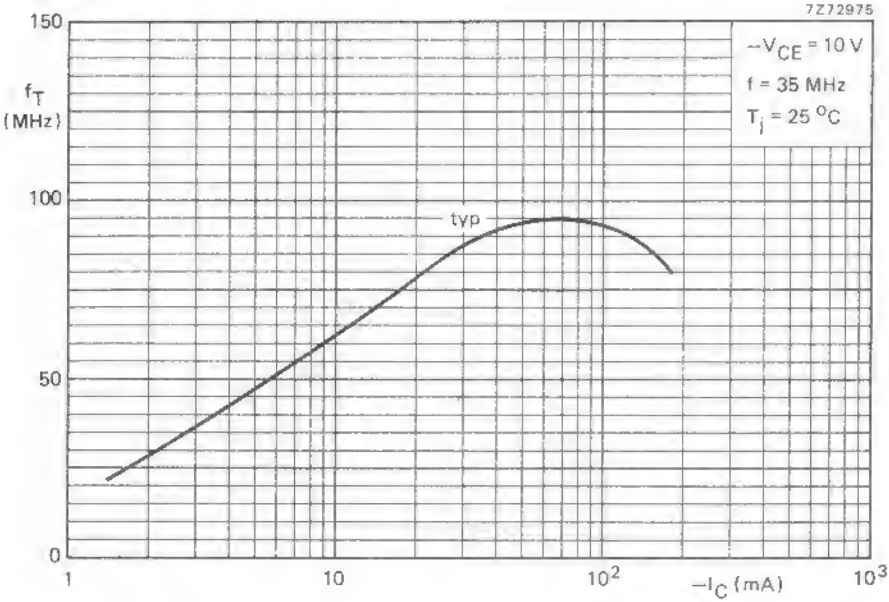

7Z72970
typical values
$T_j = 25\,^oC$
$-I_C$ (mA)
200
150
100
50
0
$-I_B = 1$ mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
0
50
100
150
$-V_{CE}$ (V)

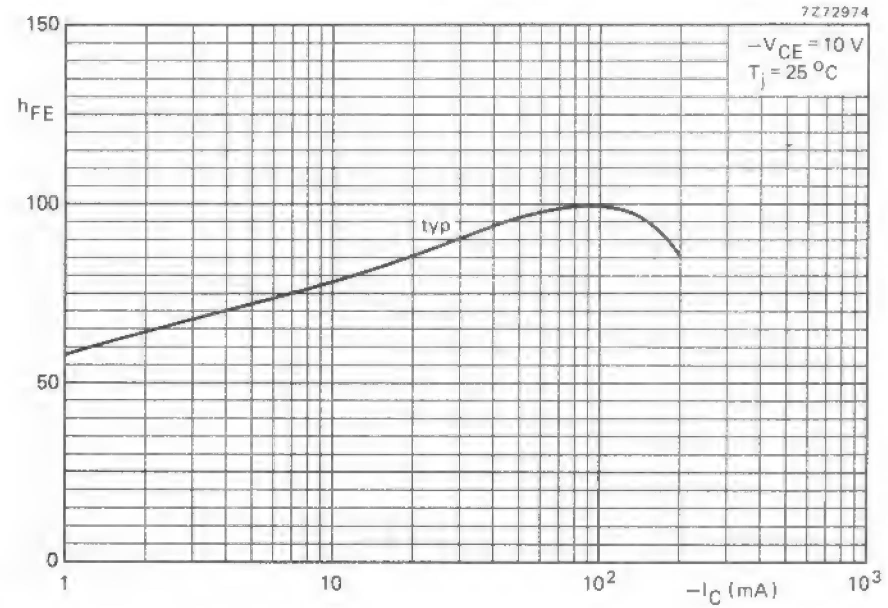

7Z72971
typical values
$T_j = 25\,^oC$
$-I_C$ (mA)
300
200
100
0
$-I_B = 5$ mA
2 mA
1 mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
0
5
10
15
20
$-V_{CE}$ (V)

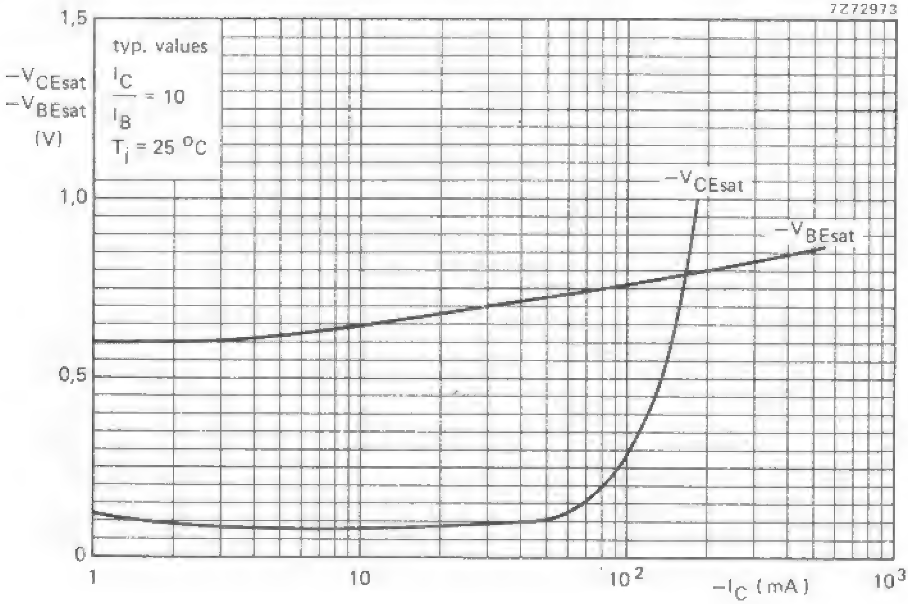

7Z72968
$-V_{CB}$ = 200 V
$-I_{CBO}$ (nA)
10^4
10^3
10^2
10
typ
0
100
200
T_j (°C)

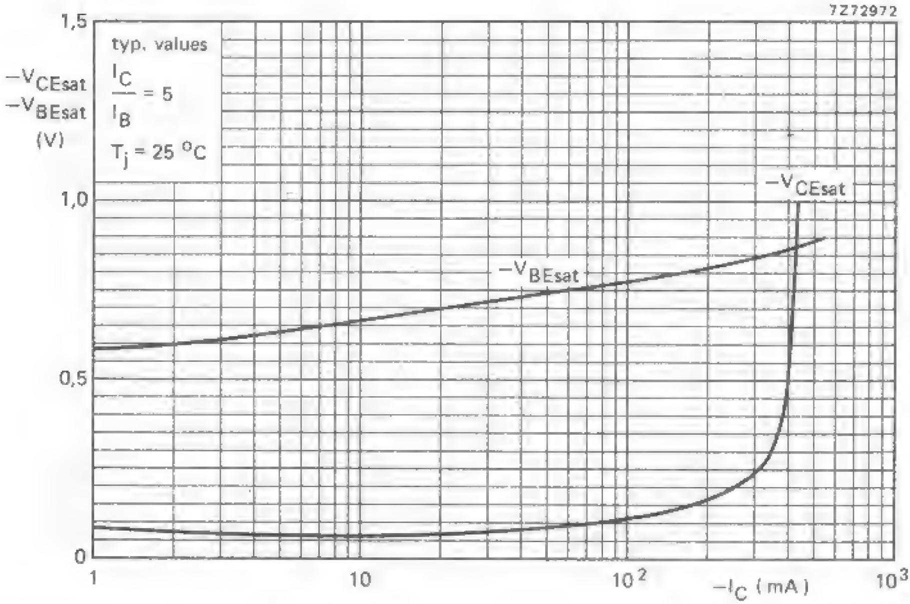

7Z72967
$-V_{CE}$ = 10 V
T_j = 25 °C
$-I_C$ (mA)
10^2
10
1
10^{-1}
typ
0,5
1,5
2,5
$-V_{BE}$ (V)


7Z72969
I_E = I_e = 0
f = 1 MHz
T_j = 25 °C
C_c (pF)
30
20
10
0
typ
0
20
40
$-V_{CB}$ (V)


7Z72975
$-V_{CE}$ = 10 V
f = 35 MHz
T_j = 25 °C
f_T (MHz)
typ
150
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)


7Z72974
$-V_{CE}$ = 10 V
T_j = 25 °C
h_{FE}
typ
150
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)


7Z72973
1,5
1,0
0,5
0
$-V_{CEsat}$
$-V_{BEsat}$
(V)
typ. values
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
$-V_{CEsat}$
$-V_{BEsat}$
1
10
10^2
$-I_C$ (mA)
10^3


7Z72972
1,5
1,0
0,5
0
$-V_{CEsat}$
$-V_{BEsat}$
(V)
typ. values
$\frac{I_C}{I_B} = 5$
$T_j = 25\ ^oC$
$-V_{CEsat}$
$-V_{BEsat}$
1
10
10^2
$-I_C$ (mA)
10^3

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes for general industrial applications.

QUICK REFERENCE DATA

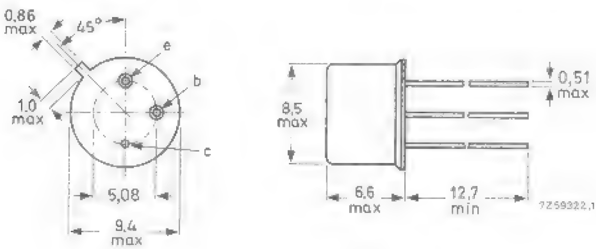
			BFX29	BFX87	BFX88	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	50	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	50	40	V
Collector current (peak value)	$-I_{CM}$	max.	600	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	600	600	600	mW
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	50	40	40	
		typ.	125	125	125	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	100	100	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-071, available on request.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BFX29	BFX87	BFX88		
$-V_{CBO}$ max.	60	50	40		V
$-V_{CEO}$ max.	60	50	40		V
$-V_{EBO}$ max.	5.0	4.0	4.0		V
$-I_C$ max.				600	mA
$-I_{CM}$ max.				600	mA
I_{EM} max.				600	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)				600	mW

Temperature

T_{stg} range	-65 to +200	^{o}C
T_j max.	+200	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	292	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

			Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current					
	$-V_{CB} = 60V$, $I_E = 0$	BFX29	-	1.0	500	nA
	$-V_{CB} = 50V$, $I_E = 0$	BFX87	-	1.0	500	nA
	$-V_{CB} = 40V$, $I_E = 0$	BFX88	-	1.0	500	nA
	$-V_{CB} = 50V$, $I_E = 0$	BFX29	-	0.5	50	nA
	$-V_{CB} = 40V$, $I_E = 0$	BEX87	-	0.5	50	nA
	$-V_{CB} = 30V$, $I_E = 0$	BFX88	-	0.5	50	nA
	$-V_{CB} = 50V$, $I_E = 0$, $T_j = 100^{o}C$	BFX29	-	0.03	2.0	μA
	$-V_{CB} = 40V$, $I_E = 0$, $T_j = 100^{o}C$	BFX87	-	0.03	2.0	μA
	$-V_{CB} = 30V$, $I_E = 0$, $T_j = 100^{o}C$	BFX88	-	0.03	2.0	μA
$-I_{EBO}$	Emitter cut-off current					
	$-V_{EB} = 5.0V$, $I_C = 0$	BFX29	-	30	500	nA
	$-V_{EB} = 4.0V$, $I_C = 0$	BFX87, 88	-	2.0	500	nA
	$-V_{EB} = 3.0V$, $I_C = 0$	BFX29, 87, BFX88	-	1.0	100	nA

ELECTRICAL CHARACTERISTICS (cont'd)

Symbol	Parameter / Conditions	Type	Min.	Typ.	Max.	Unit
h_{FE}	Static forward current transfer ratio					
	$-I_C = 0.1mA$, $-V_{CE} = 10V$	BFX29	20	90	-	
	$-I_C = 1.0mA$, $-V_{CE} = 10V$	BFX29, 87, BFX88	40	105	-	
	$-I_C = 10mA$, $-V_{CE} = 10V$	BFX29	50	125	-	
		BFX87, 88	40	125	-	
	$-I_C = 50mA$, $-V_{CE} = 10V$	BFX29	50	125	-	
	$-I_C = 150mA$, $-V_{CE} = 10V$	BFX29, 87, BFX88	40	90	-	
	$-I_C = 500mA$, $-V_{CE} = 10V$	BFX87, 88	25	40	-	
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C = 150mA$, $-I_B = 15mA$		-	0.15	0.40	V
$-V_{BE(sat)}$	Base-emitter saturation voltage					
	$-I_C = 30mA$, $-I_B = 1.0mA$		-	0.77	0.90	V
	$-I_C = 150mA$, $-I_B = 15mA$		-	1.05	1.30	V
C_{tc}	Collector capacitance					
	$-V_{CB} = 10V$, $I_E = I_e = 0$, $f = 1.0MHz$		-	6.0	12	pF
C_{te}	Emitter capacitance					
	$-V_{EB} = 2.0V$, $I_C = I_c = 0$, $f = 1.0MHz$		-	18	30	pF
f_T	Transition frequency					
	$-I_C = 50mA$, $-V_{CE} = 10V$, $f = 100MHz$, $T_{amb} = 25^{\circ}C$		100	360	-	MHz

ELECTRICAL CHARACTERISTICS (cont'd)

Saturated switching times (see test circuits)

		Min.	Typ.	Max.	
t_{on}	Turn-on time	-	25	60	ns
t_{off}	Turn-off time	-	55	150	ns

h-parameters

Measured at $-I_C = 10mA$, $-V_{CE} = 10V$, $f = 1.0kHz$, $T_{amb} = 25^{\circ}C$

		Min.	Typ.	Max.	
h_{ie}	Input impedance	-	600	-	Ω
h_{re}	Voltage feedback ratio	-	1.50	-	$\times 10^{-4}$
h_{fe}	Forward current transfer ratio	-	155	-	
h_{oe}	Output admittance	-	104	-	μmho

SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored at temperatures above 100°C before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.

TEST CIRCUITS

Saturated turn-on switching time

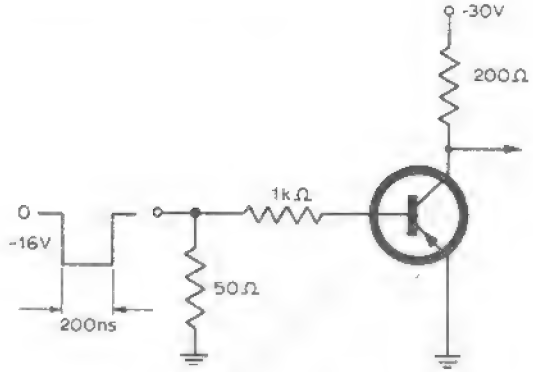


Fig.1

Saturated turn-off switching time

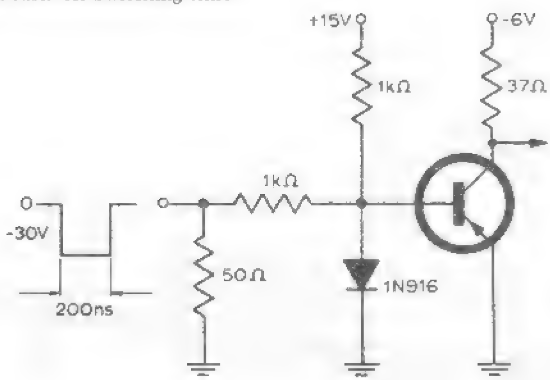
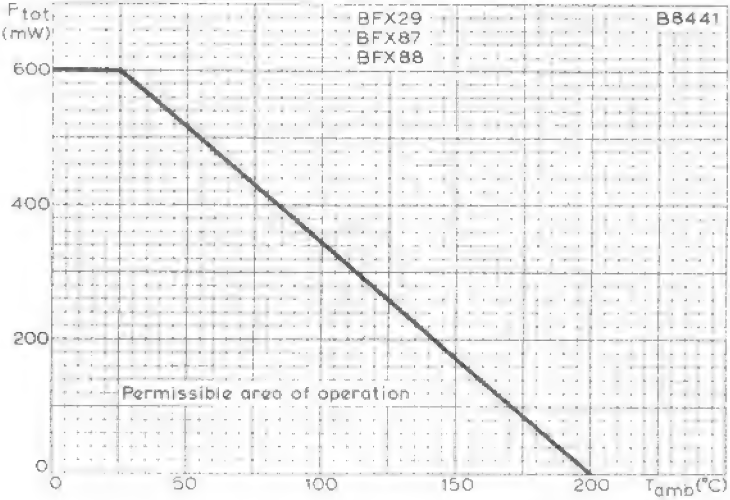
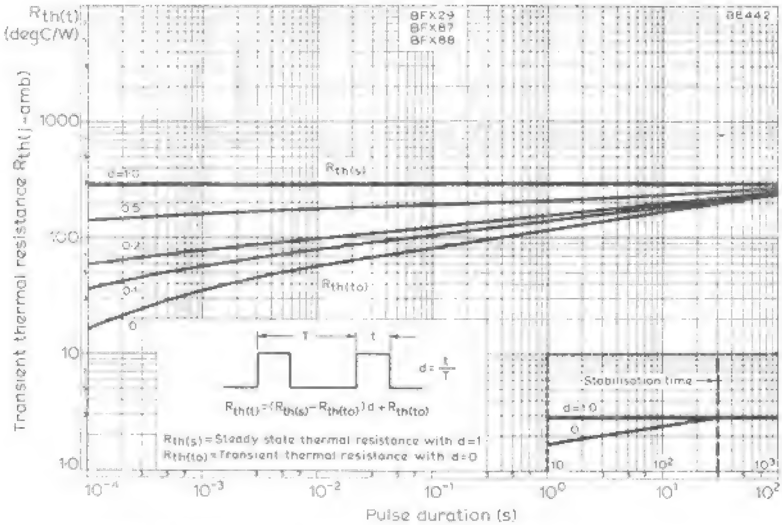


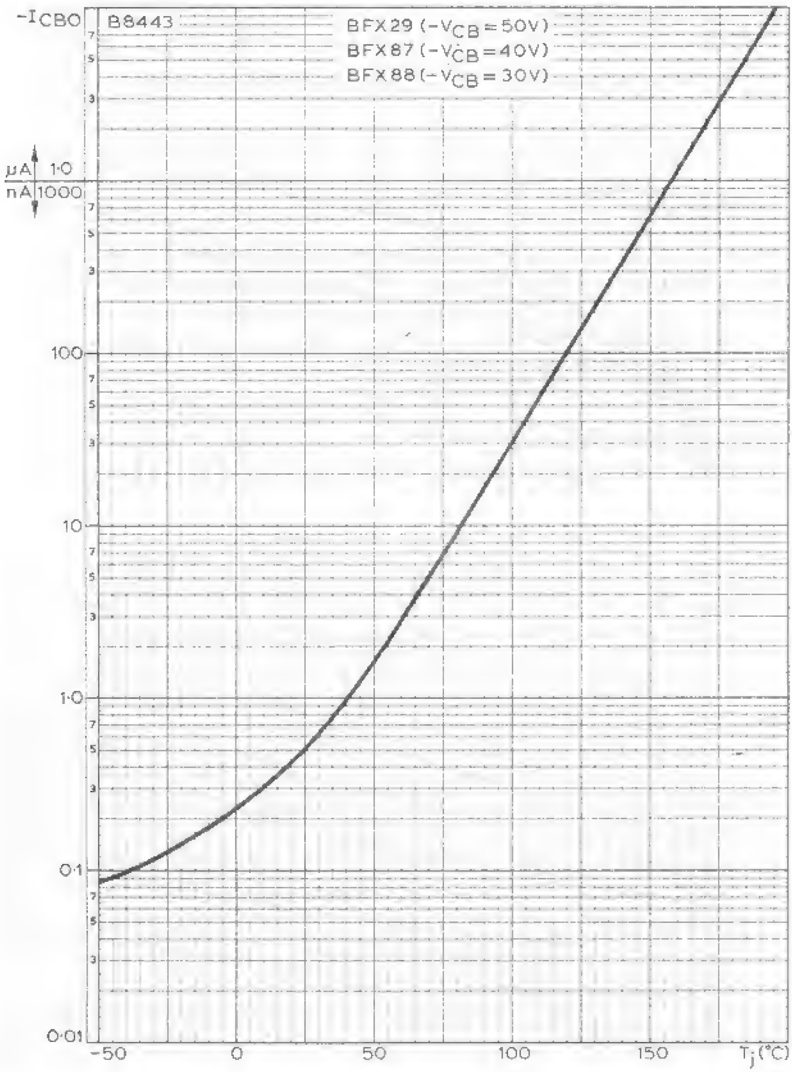
Fig.2



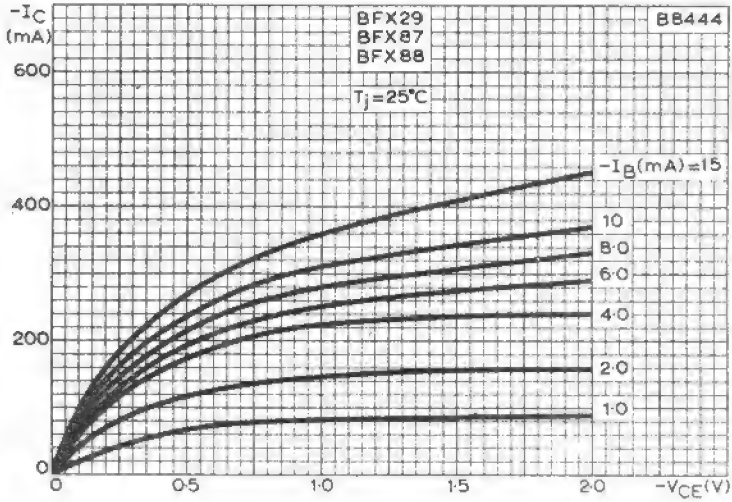
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

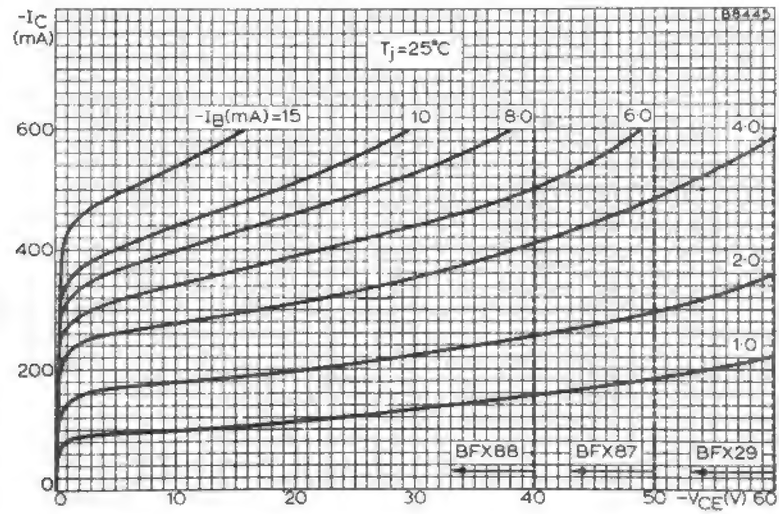


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

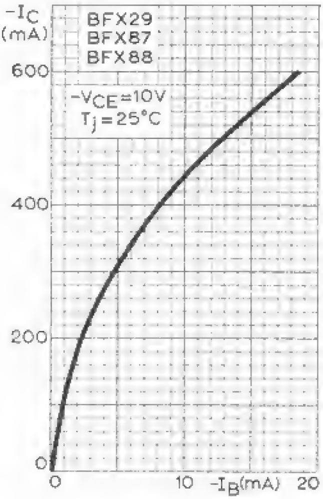


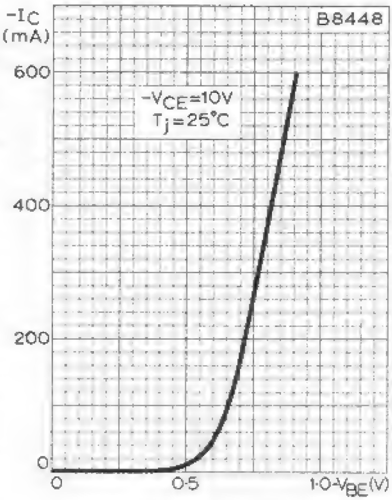
TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT
WITH JUNCTION TEMPERATURE



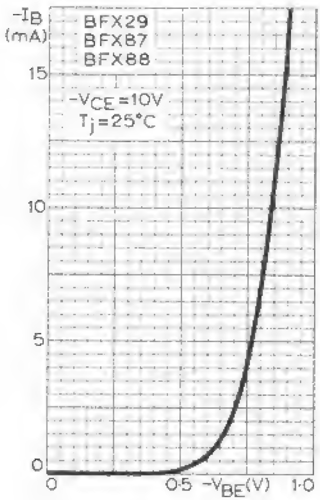


TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH COLLECTOR-EMITTER VOLTAGES

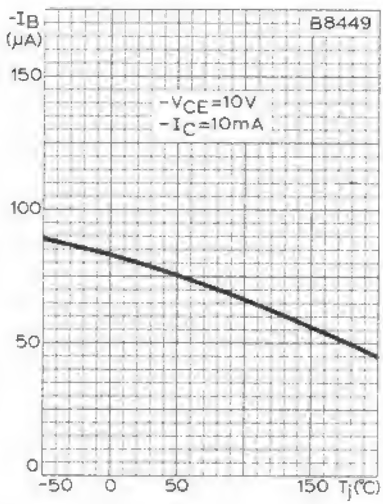




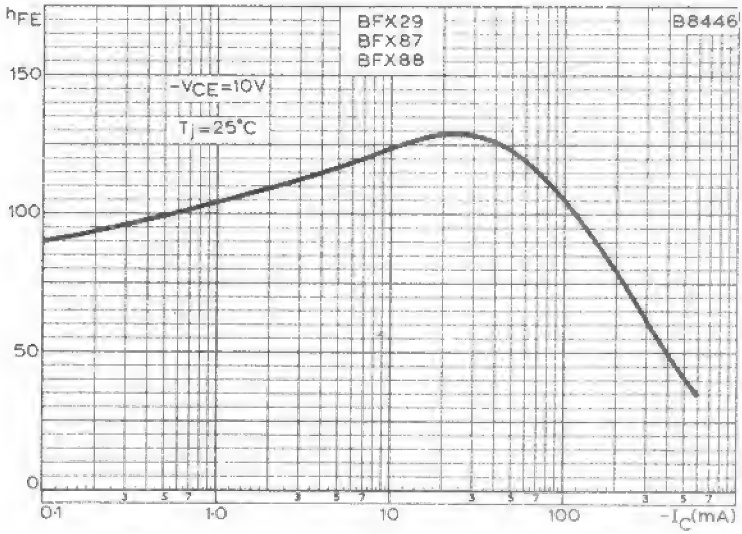
TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS

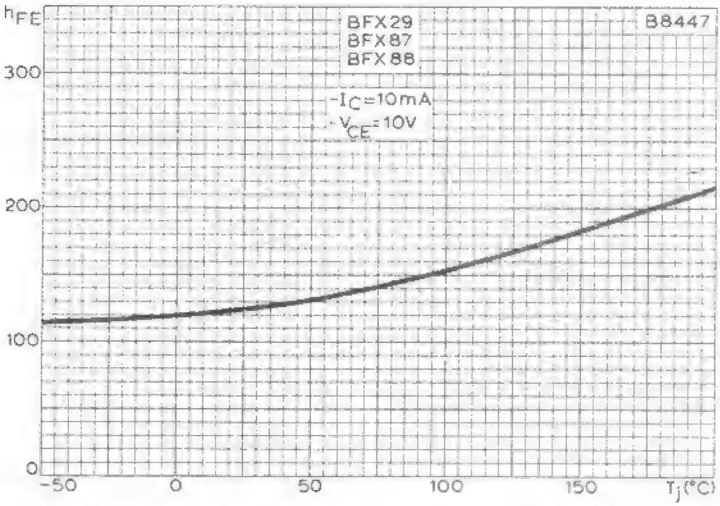


Typical input characteristic

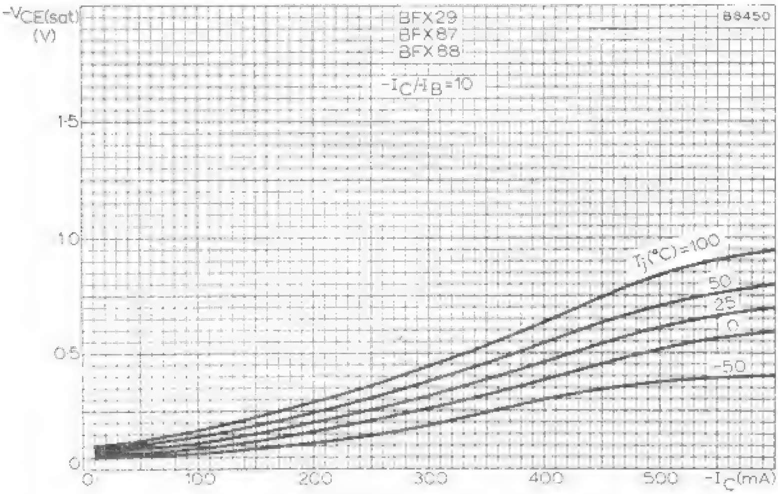


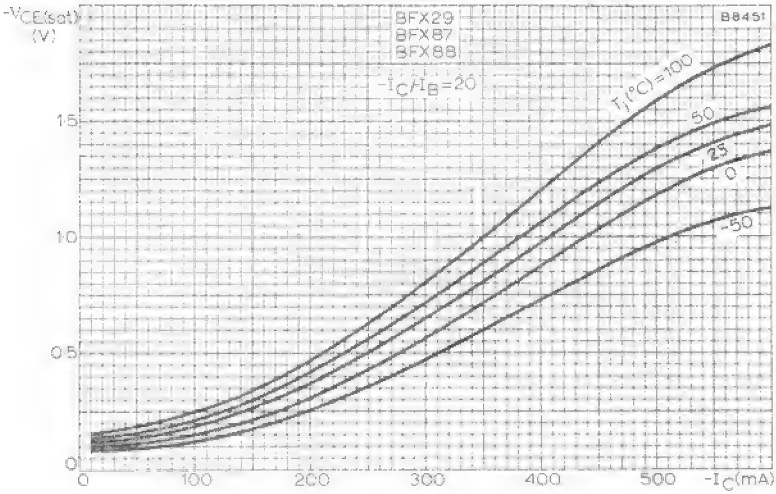
Typical base current versus junction temperature



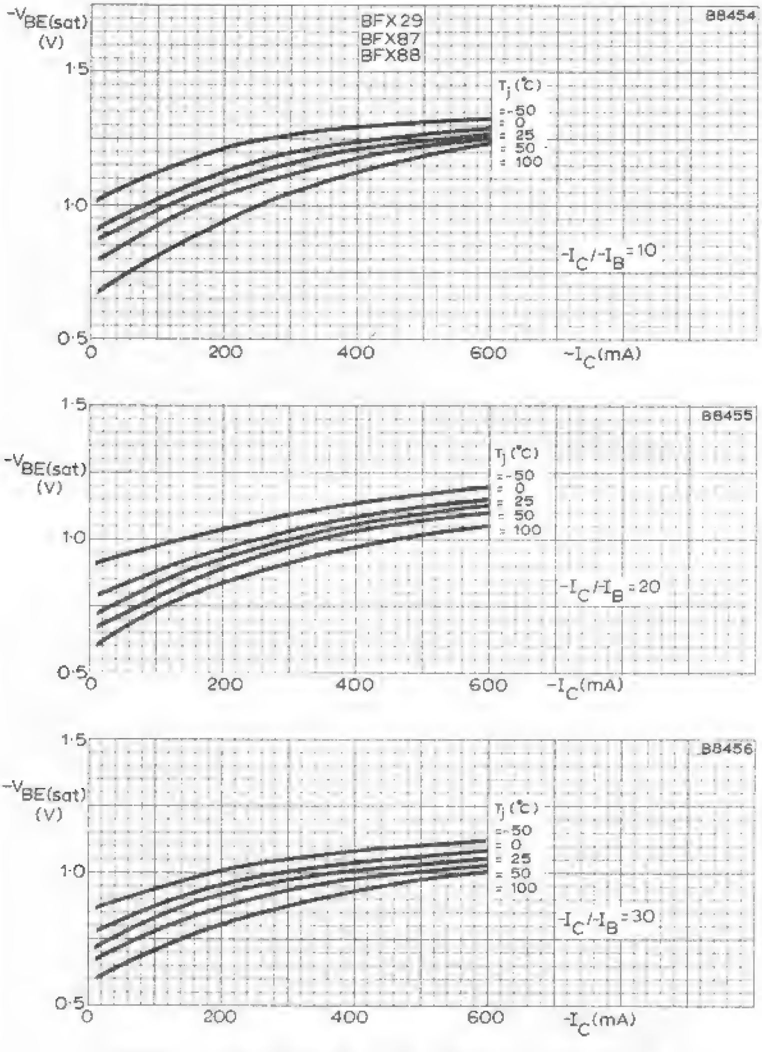


TYPICAL VATIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE

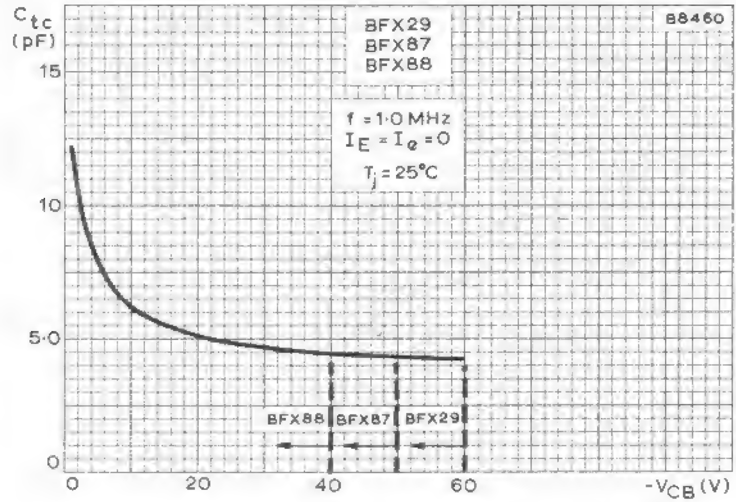




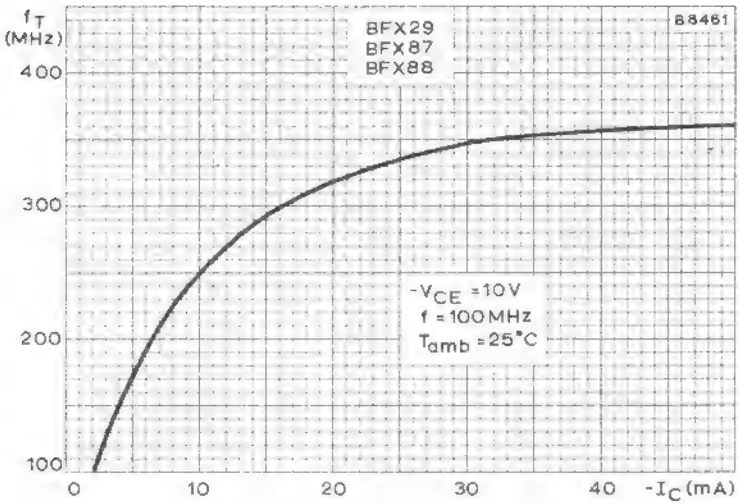
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



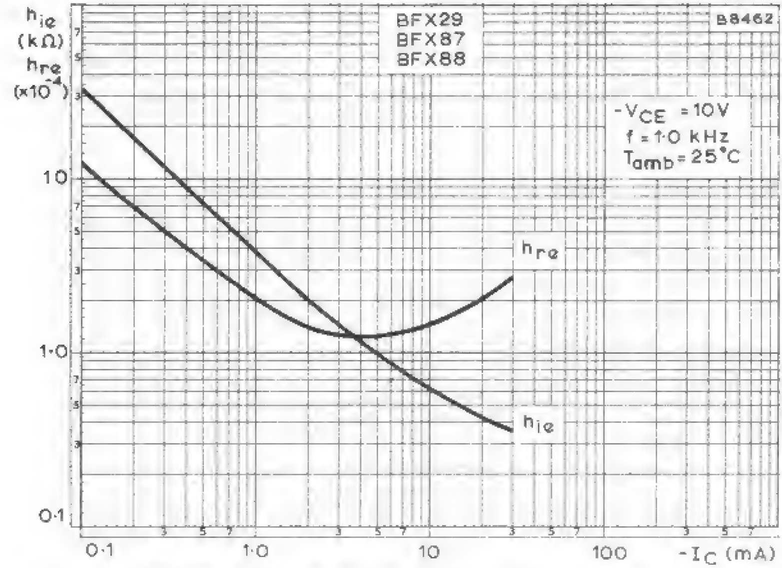
TYPICAL VARIATION OF BASE-EMITTER SATURATION
VOLTAGE WITH COLLECTOR CURRENT



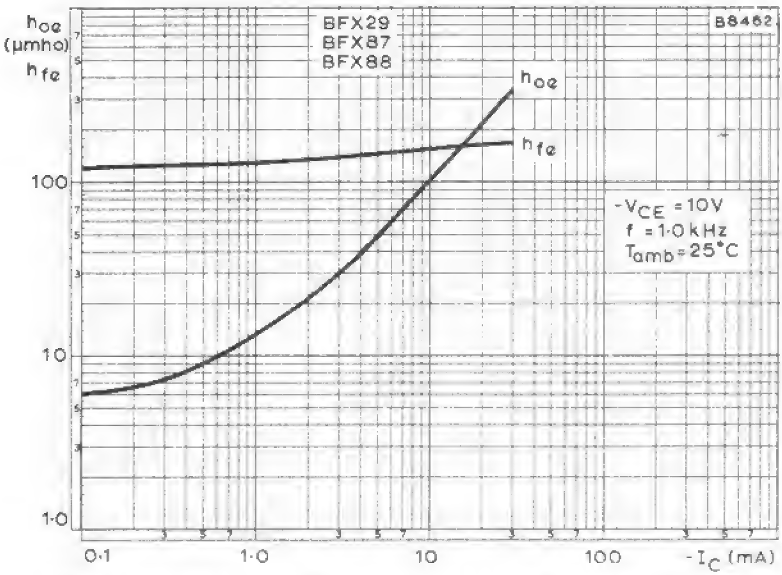
TYPICAL VARIATION OF COLLECTOR CAPACITANCE WITH COLLECTOR-BASE VOLTAGE



TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT



TYPICAL INPUT IMPEDANCE AND TYPICAL VOLTAGE FEEDBACK RATIO PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL FORWARD CURRENT TRANSFER RATIO AND TYPICAL OUTPUT ADMITTANCE PLOTTED AGAINST COLLECTOR CURRENT

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a TO-39 metal envelope intended for switching applications.

QUICK REFERENCE DATA

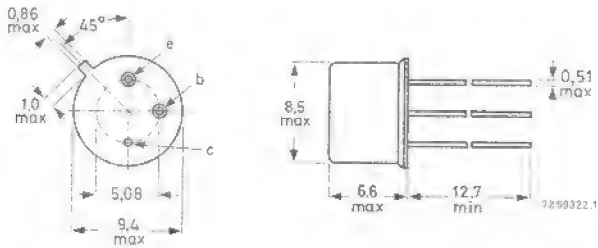
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	65	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	V
Collector current (peak value)	$-I_{CM}$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	600	mW
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 0,4 V	h_{FE}	typ.	90	
			50 to 200	
Storage time $-I_{Con}$ = 100 mA; $-I_{Bon}$ = I_{Boff} = 10 mA	t_s	<	250	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-083, available on request.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

$-V_{CBO}$ max.	65	V
$-V_{CEO}$ max.	65	V
$-V_{EBO}$ max.	5.0	V
$-I_C$ max.	600	mA
$-I_{CM}$ max.	600	mA
$-I_{EM}$ max.	600	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)	600	mW

Temperature

T_{stg} min.	-65	^oC
T_{stg} max.	200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	292	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$-V_{CB} = 65V$, $I_E = 0$	-	1.0	500	nA
	$-V_{CB} = 50V$, $I_E = 0$	-	0.5	50	nA
	$-V_{CB} = 50V$, $I_E = 0$, $T_j = 100^oC$	-	0.03	2.0	μA
$-I_{EBO}$	Emitter cut-off current				
	$-V_{EB} = 5.0V$, $I_C = 0$	-	30	500	nA
	$-V_{EB} = 3.0V$, $I_C = 0$	-	1.0	100	nA
$-V_{BE(sat)}$	Base-emitter saturation voltage				
	$-I_C = 30mA$, $-I_B = 1.0mA$	-	0.77	0.90	V
	$-I_C = 150mA$, $-I_B = 15mA$	-	1.05	1.30	V
h_{FE}	Static forward current transfer ratio				
	$-I_C = 1.0mA$, $-V_{CE} = 0.4V$	40	80	-	
	$-I_C = 10mA$, $-V_{CE} = 0.4V$	50	90	200	
	$-I_C = 50mA$, $-V_{CE} = 0.4V$	20	92	-	
	$-I_C = 150mA$, $-V_{CE} = 0.4V$	10	50	-	

ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
C_{tc}	Collector capacitance $-V_{CB}=10V$, $I_E=I_e=0$, $f=1.0MHz$	–	6.0	12	pF
C_{te}	Emitter capacitance $-V_{EB}=2.0V$, $I_C=I_c=0$, $f=1.0MHz$	–	18	30	pF

Saturated switching times (see page 4)

$-I_C=100mA$, $-I_{Bon}=I_{Boff}=10mA$, $V_{EE}=10V$, $V_{BEoff}=2.0V$

		Min.	Typ.	Max.	
t_d	Delay time	–	9	15	ns
t_r	Rise time	–	18	40	ns
t_{on}	Turn-on time (t_d+t_r)	–	27	50	ns
t_s	Storage time	–	95	250	ns
t_f	Fall time	–	30	50	ns
t_{off}	Turn-off time (t_s+t_f)	–	125	290	ns

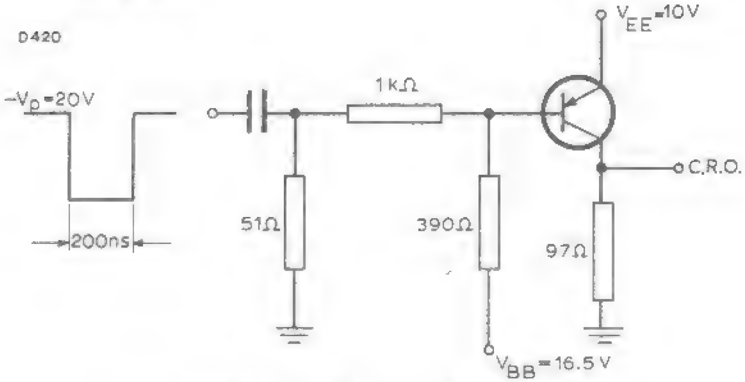
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of $245^{o}C$ for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored at temperatures above $100^{o}C$ before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.

ELECTRICAL CHARACTERISTICS (cont'd)

Saturated switching times

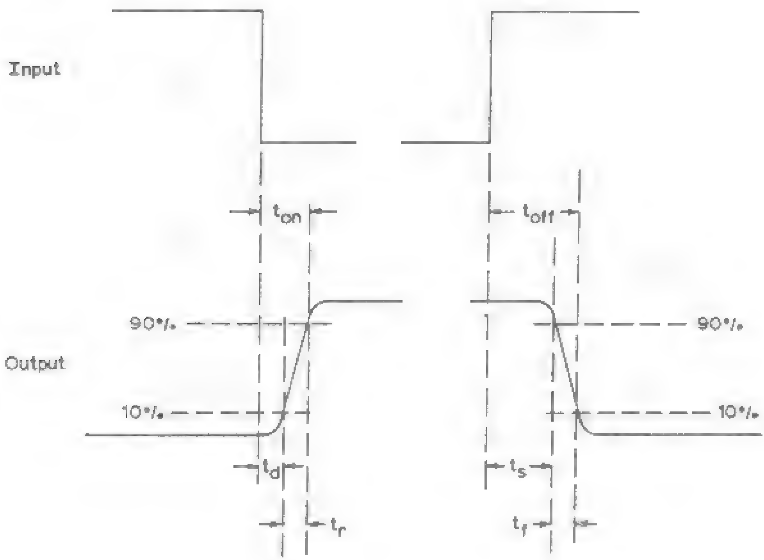
Test circuit

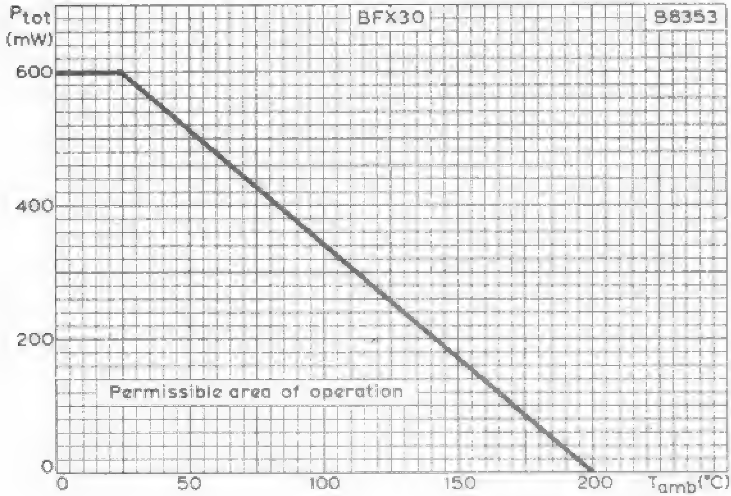


$-I_C = 100mA, -I_{B(on)} = I_{B(off)} = 10mA$

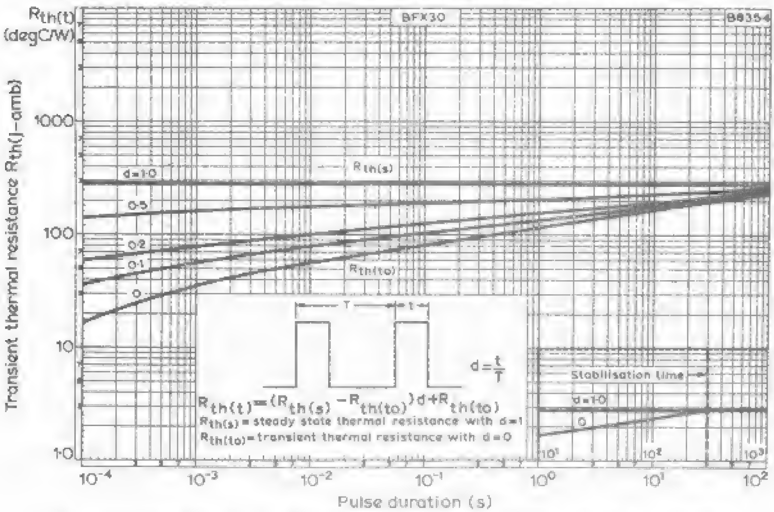
$V_{BE(off)} = 2 \cdot 0V$

Waveforms

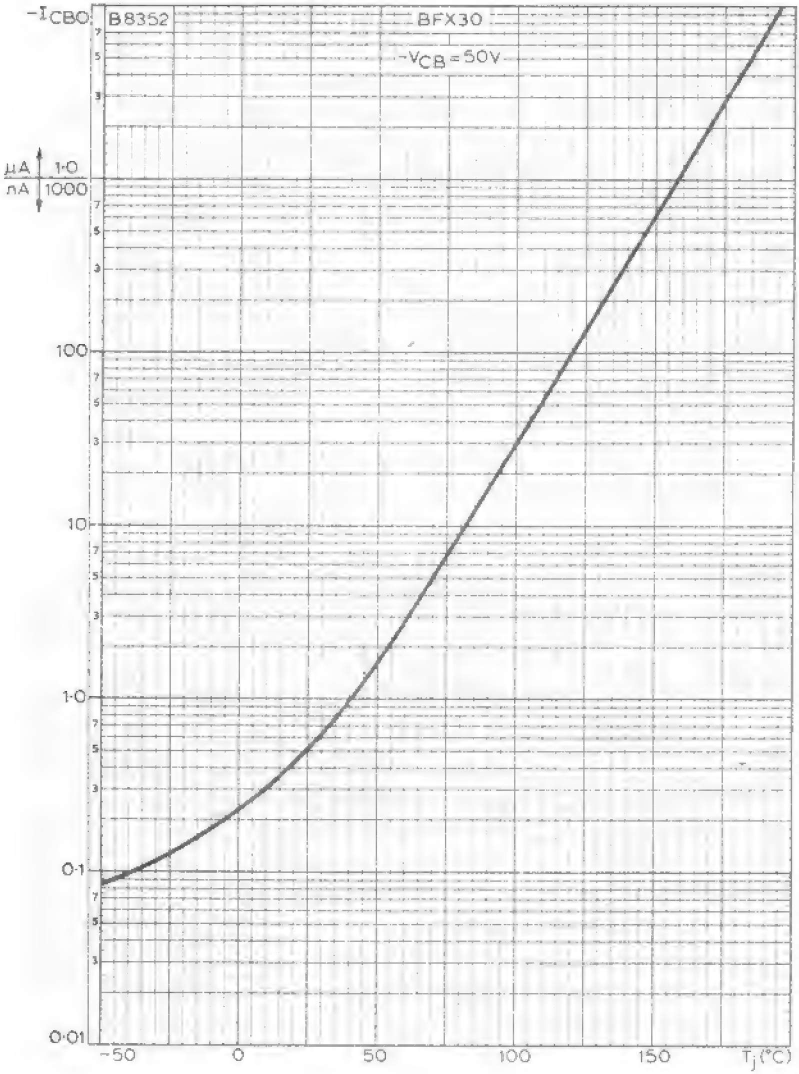




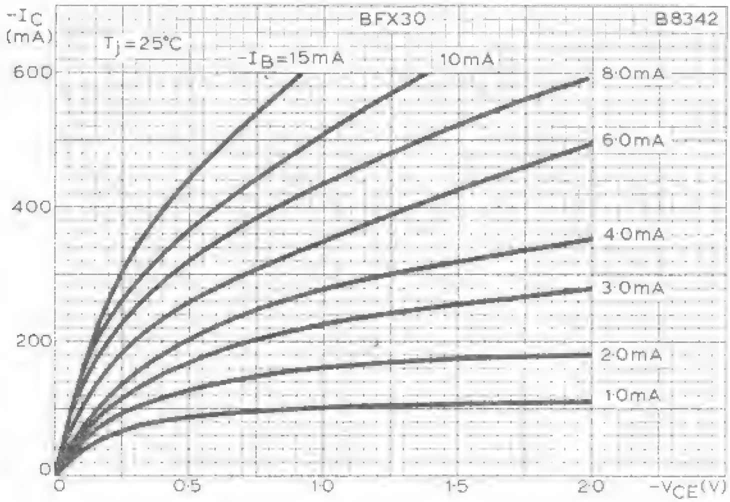
TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

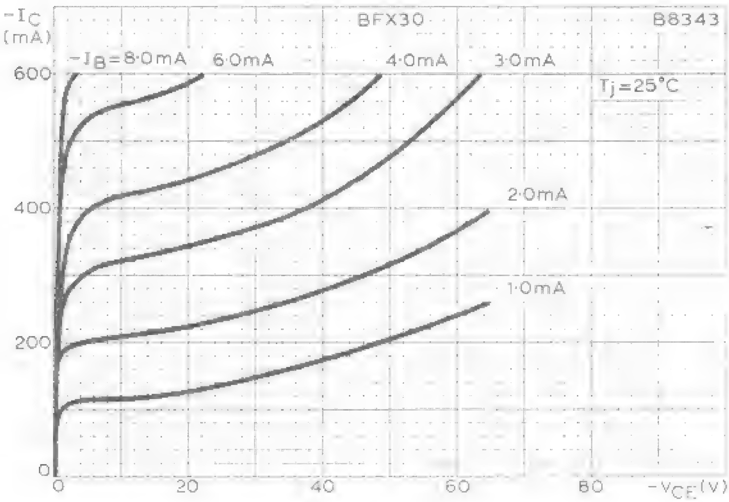


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

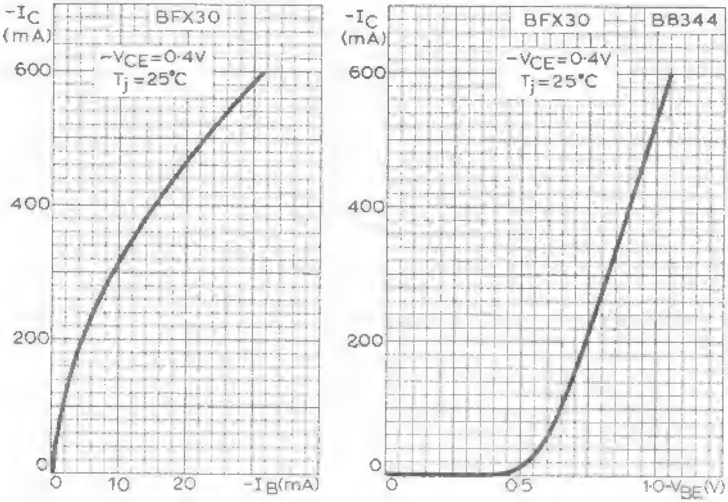


TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT
WITH JUNCTION TEMPERATURE

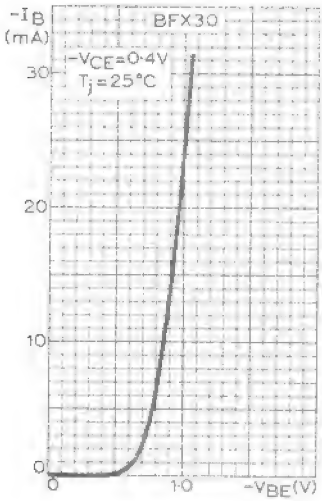




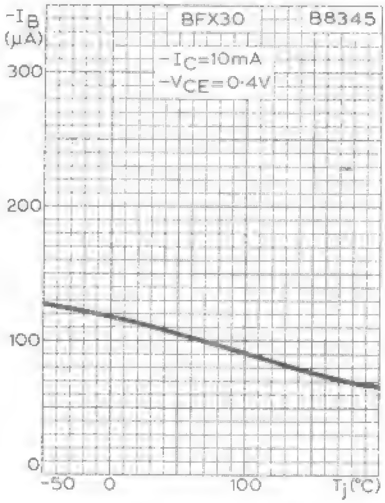
TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH COLLECTOR-EMITTER VOLTAGES



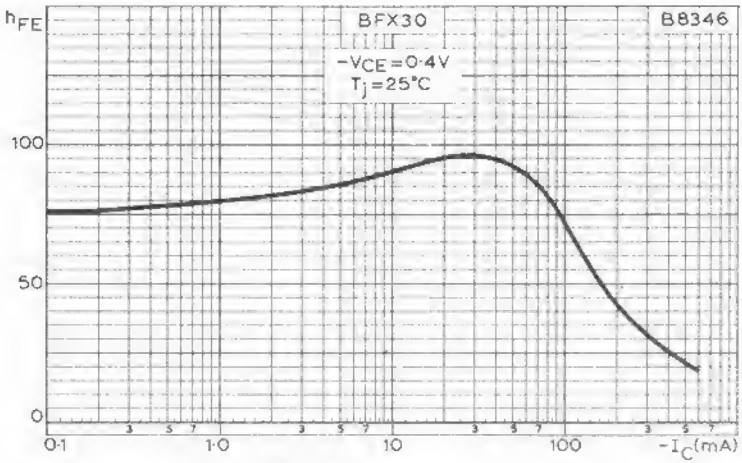
TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS

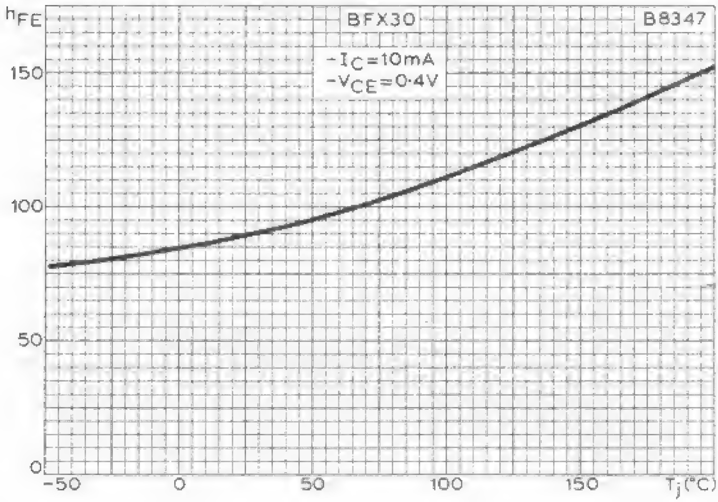


Typical input characteristics

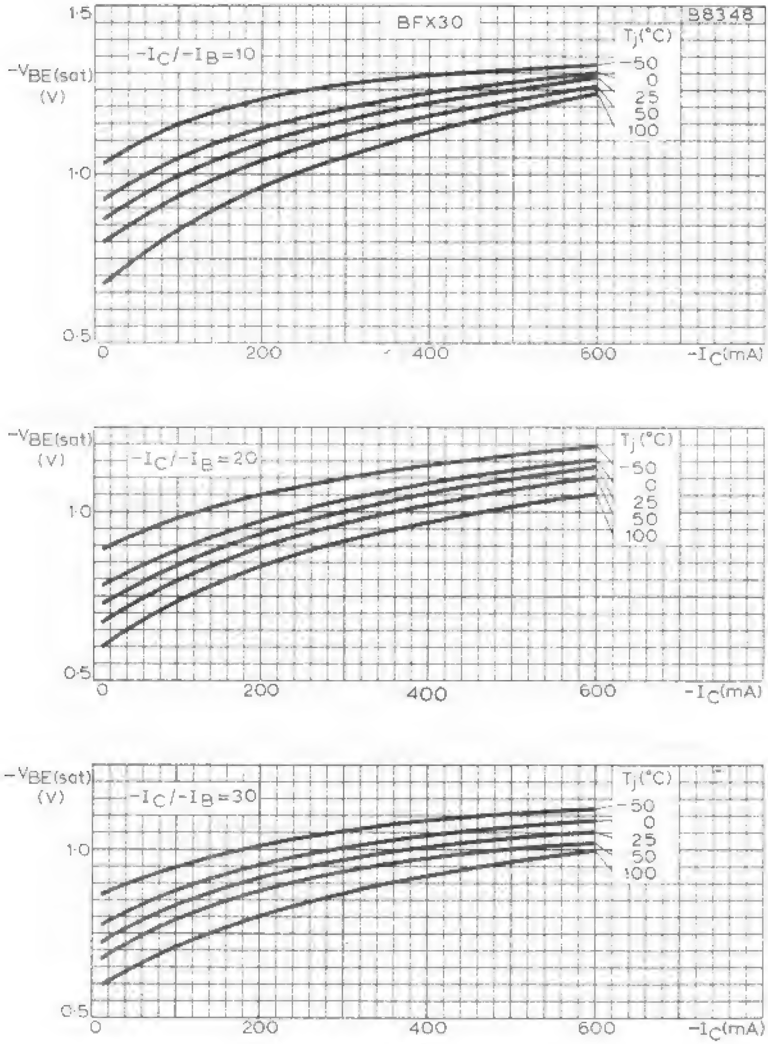


Typical base current versus junction temperature

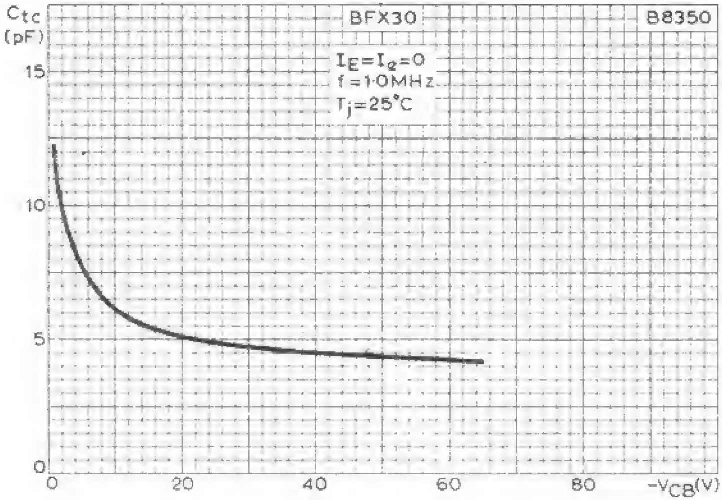




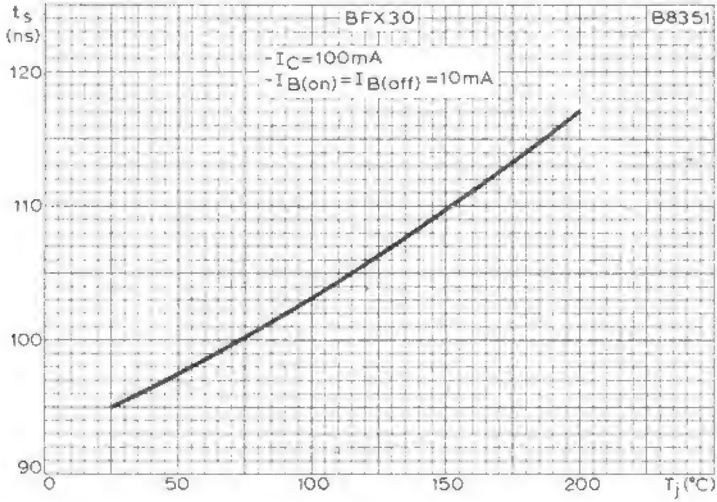
TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO
WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE



TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT AND I_C/I_B RATIO



TYPICAL VARIATION OF COLLECTOR CAPACITANCE WITH COLLECTOR-BASE VOLTAGE



TYPICAL VARIATION OF STORAGE TIME WITH JUNCTION TEMPERATURE

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-39 metal envelope primarily intended for use as high-current switching device, e.g. inverters and switching regulators.

QUICK REFERENCE DATA

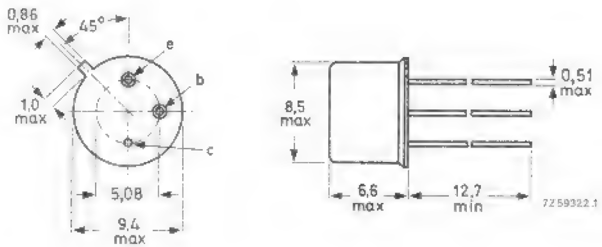
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	40 to	150	
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	>	70	MHz
Turn-off time when switched from I_C = 5 A; I_B = 0,5 A to cut-off with $-I_{BM}$ = 0,5 A	t_{off}	<	1,2	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56254 (distance disc).

Products approved to CECC 50 004-025, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Currents				
Collector current (d.c.)	I_C	max.	2.0	A
Collector current (peak value)	I_{CM}	max.	5.0	A
Base current (d.c.)	I_B	max.	1.0	A
Power dissipation				
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5.0	W
up to T_{amb} = 25 °C	P_{tot}	max.	0.87	W
Temperatures				
Storage temperature	T_{stg}	-55 to +200		°C
Junction temperature	T_j	max.	200	°C

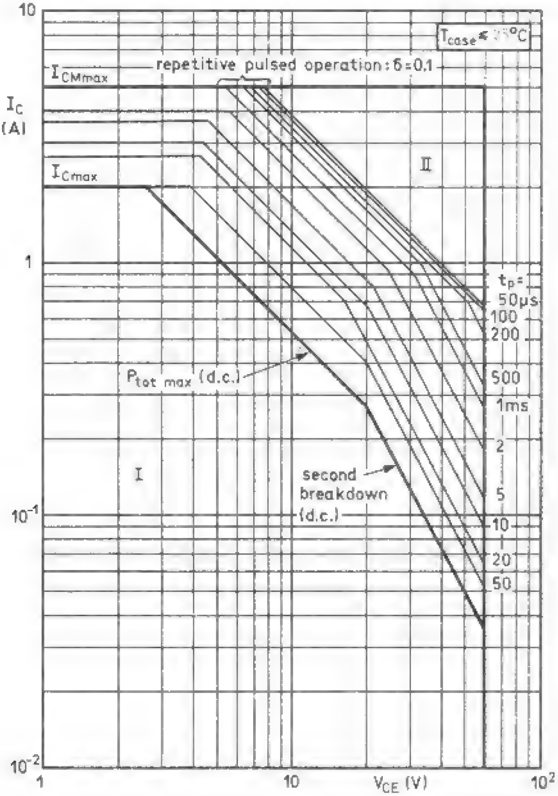
THERMAL RESISTANCE

Frm junction to ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W

CHARACTERISTICS

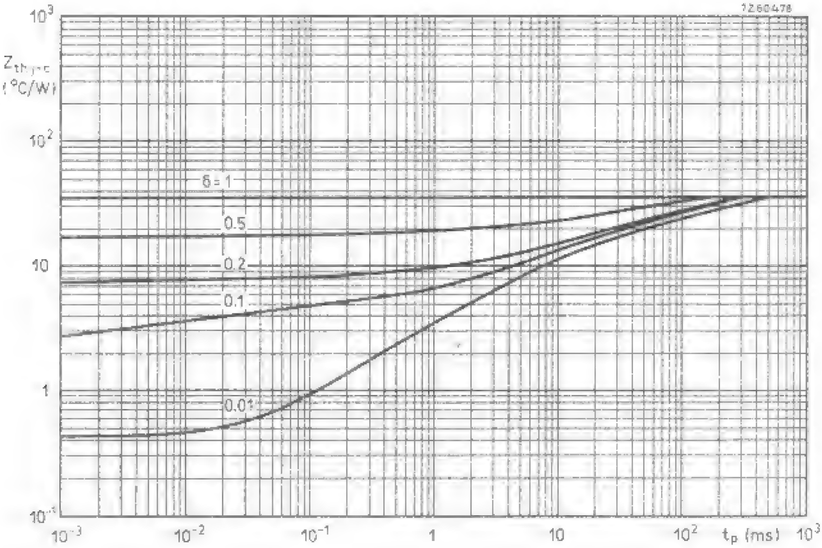
T_j = 25 °C unless otherwise specified

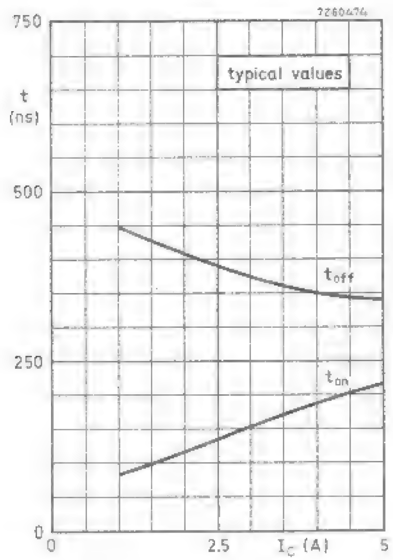
Collector cut-off current V_{EB} = 0; V_{CE} = 60 V	I_{CES}	<	10 μA
Emitter cut-off current I_C = 0; V_{EB} = 4 V	I_{EBO}	typ. <	0,01 μA 10 μA
Saturation voltage I_C = 5 A; I_B = 0,5 A	V_{CEsat}	typ. <	0,77 V 1,0 V
	V_{BEsat}	typ. <	1,43 V 1,8 V
D.C. current gain I_C = 1,0 A; V_{CE} = 2,0 V	h_{FE}	typ.	130
I_C = 1,5 A; V_{CE} = 0,6 V	h_{FE}	typ.	60
I_C = 2,0 A; V_{CE} = 2,0 V	h_{FE}	typ.	110 40 to 150
Collector capacitance at f = 1 MHz I_E = I_e = 0; V_{CB} = 10 V	C_c	typ. <	36 pF 100 pF
Emitter-capacitance at f = 1 MHz I_C = I_c = 0; V_{EB} = 0,5 V	C_e	typ.	440 pF ←
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	> typ.	70 MHz 100 MHz
Turn on time when switched from $-V_{BE}$ = 2,0 V to I_C = 5 V; I_B = 0,5 A with I_{BM} = 0,5 A	t_{on}	typ. <	0,2 μs 0,6 μs
Turn off time when switched from I_C = 5 A; I_B = 0,5 A to $-V_{BE}$ = 2,0 V with $-I_{BM}$ = 0,5 A	t_{off}	typ. <	0,34 μs 1,2 μs

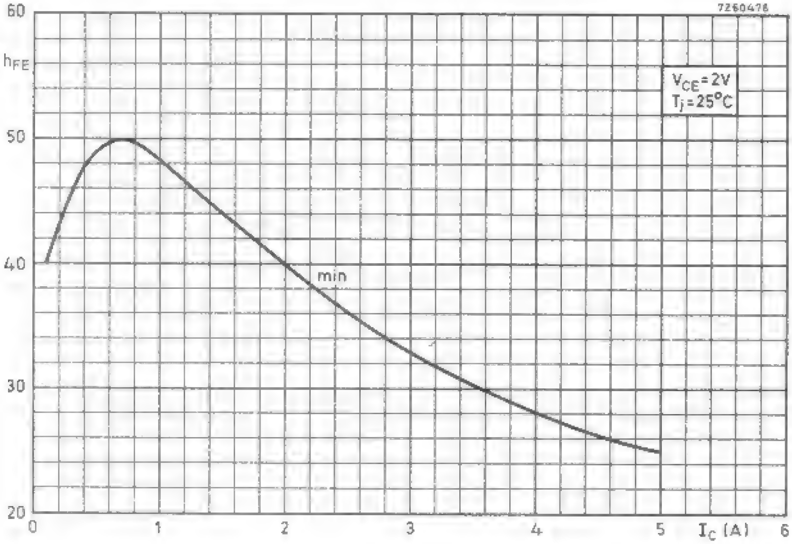


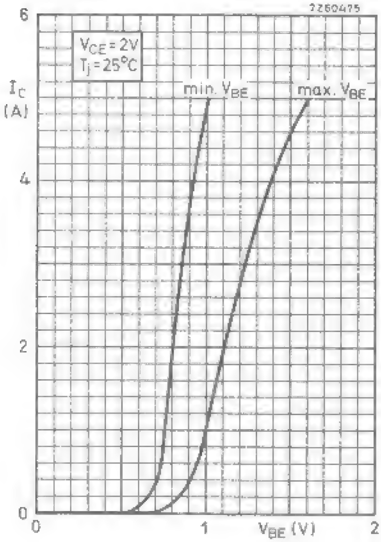
Safe Operation Area with the transistor forward biased

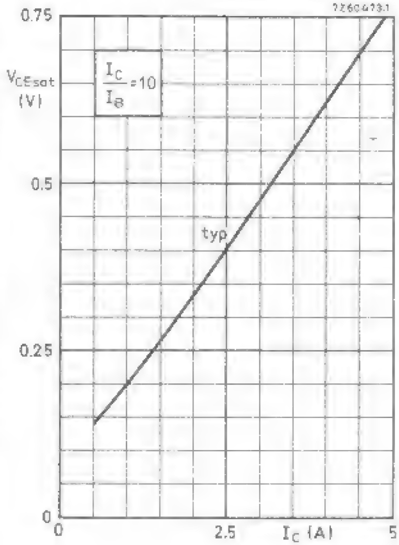
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation


7Z60478
$Z_{th\,j\text{-}c}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
typical values
t (ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
h_{FE}
V_{CE} = 2V
T_j = 25°C
min
60
50
40
30
20
0
1
2
3
4
5
I_C (A)
6


7Z60475
V_{CE} = 2V
T_j = 25°C
I_C (A)
min. V_{BE}
max. V_{BE}
6
4
2
0
0
1
V_{BE} (V)
2


7Z60473.1
V_{CEsat} (V)
$\frac{I_C}{I_B}$ = 10
typ
0.75
0.5
0.25
0
0
2.5
I_C (A)
5

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes for general purpose industrial applications.

QUICK REFERENCE DATA

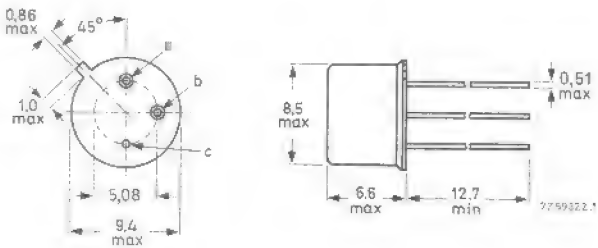
			BFX84	BFX85	BFX86	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	100	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	35	V
Collector current (peak value)	I_{CM}	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
Total power dissipation up to T_{case} = 100 °C	P_{tot}	max.	2,86	2,86	2,86	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	> typ.	30 112	70 142	70 142	
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 10 V; T_{amb} = 25 °C	f_T	>	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-100, available on request.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BFX84	BFX85	BFX86	
V_{CBO} max.	100	100	40	V
V_{CE} max. (cut-off, $I_C \leq 1mA$)	100	100	40	V
V_{CEO} max.	60	60	35	V
V_{EBO} max.		6.0		V
I_C max.		1.0		A
I_{CM} max.		1.0		A
$-I_E$ max.		1.0		A
$-I_{EM}$ max.		1.0		A
I_B max.		100		mA
$\pm I_{BM}$ max.		100		mA
P_{tot} max. $T_{amb} \leq 25^{\circ}C$		800		mW
$T_{case} \leq 25^{\circ}C$		5.0		W
$T_{case} > 25, < 100^{\circ}C$		2.86		W

Temperature

T_{stg}	-65 to +200	$^{\circ}C$
T_j max.	200	$^{\circ}C$

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

BFX84

ELECTRICAL CHARACTERISTICS ($T_j = 25^{\circ}C$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 100V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 100V$, $I_E = 0$, $T_j = 100^{\circ}C$	-	0.5	30	μA
	$V_{CB} = 80V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^{\circ}C$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^{\circ}C$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	20	80	-	
	$I_C = 150mA$, $V_{CE} = 10V$	30	112	-	
	$I_C = 500mA$, $V_{CE} = 10V$	20	70	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	7.0	12	pF

BFX84

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	140	-	MHz

Saturated switching times

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$,
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		Min.	Typ.	Max.	
t_d	Delay time	-	15	-	ns
t_r	Rise time	-	40	-	ns
t_{on}	Turn-on time	-	55	-	ns
t_s	Storage time	-	300	-	ns
t_f	Fall time	-	60	-	ns
t_{off}	Turn-off time	-	360	-	ns

h-parameters

		Min.	Typ.	Max.	
h_{fe}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	10	65	-	-
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	750	-	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		15	80	-	
h_{oe}		-	35	80	µmho

BFX85

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 100V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 100V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 80V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	50	90	-	
	$I_C = 150mA$, $V_{CE} = 10V$	70	142	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	7.0	12	pF

BFX85/BFX86

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	185	-	MHz

Saturated switching times

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$,
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		Min.	Typ.	Max.	
t_d	Delay time	-	15	-	ns
t_r	Rise time	-	40	-	ns
t_{on}	Turn-on time	-	55	-	ns
t_s	Storage time	-	300	-	ns
t_f	Fall time	-	60	-	ns
t_{off}	Turn-off time	-	360	-	ns

h-parameters

		Min.	Typ.	Max.	
h_{fe}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	20	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	750	-	Ω
h_{re}		-	0.85	5.0×10^{-4}	
h_{fe}		25	80	-	
h_{oe}		-	35	80	μmho

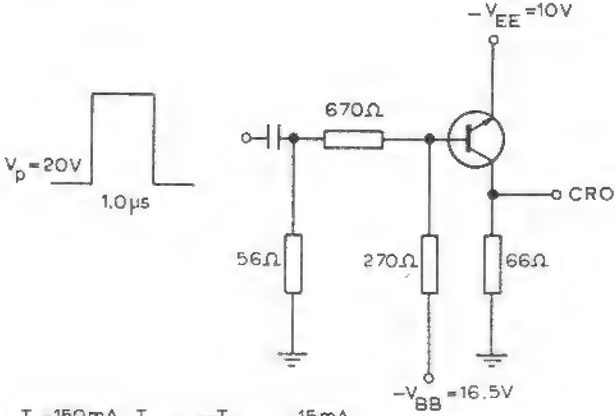
BFX86

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 40V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 30V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 30V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	50	90	-	
	$I_C = 150mA$, $V_{CE} = 10V$	70	142	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	7.0	12	pF

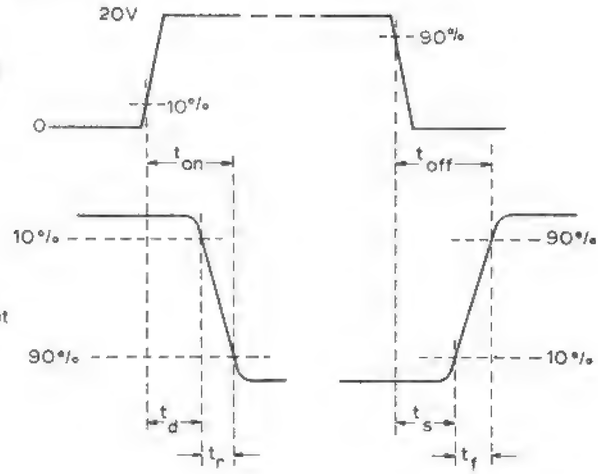
MEASUREMENT OF SATURATED SWITCHING TIMES

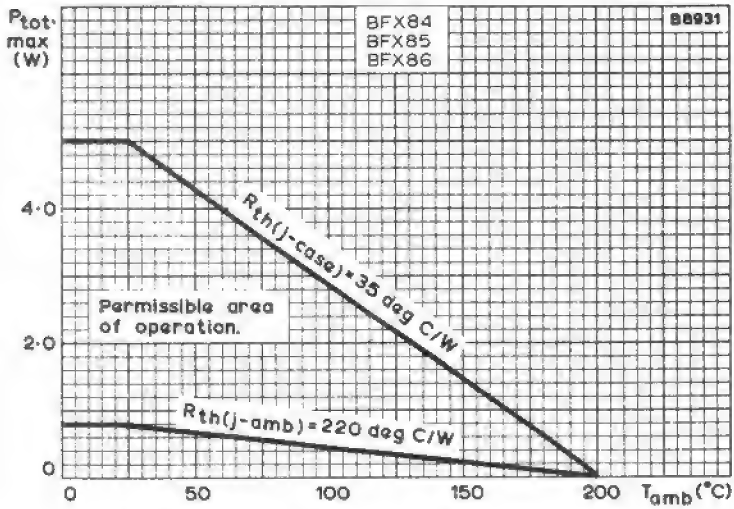
Test circuit



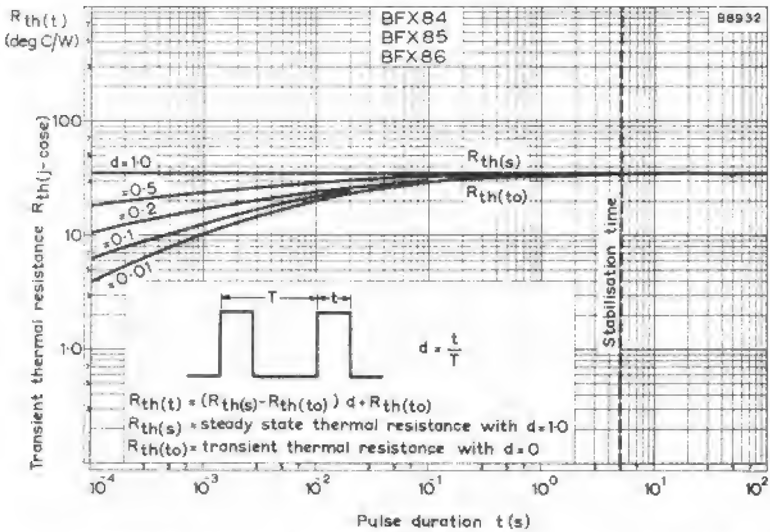
I_C = 150mA, $I_{B(on)} = -I_{B(off)}$ = 15mA
$-V_{BE(off)}$ = 2.0 V

Switching waveforms

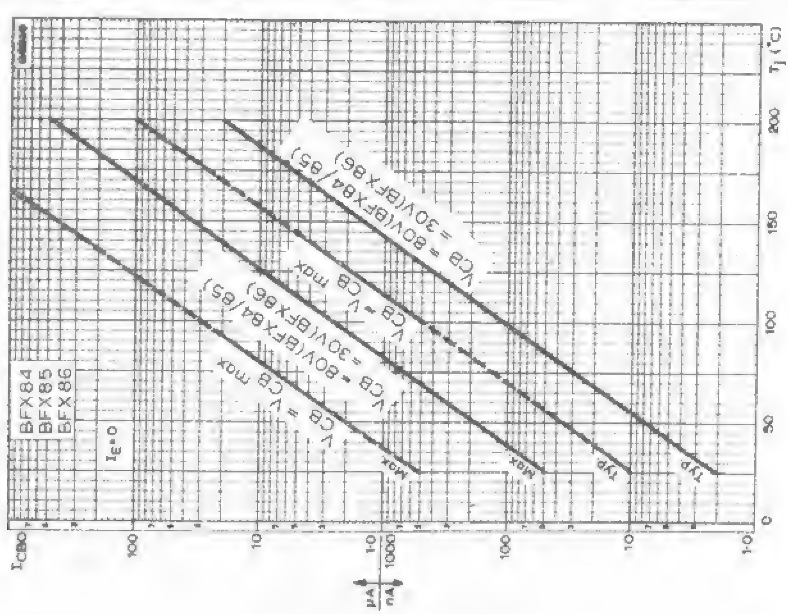


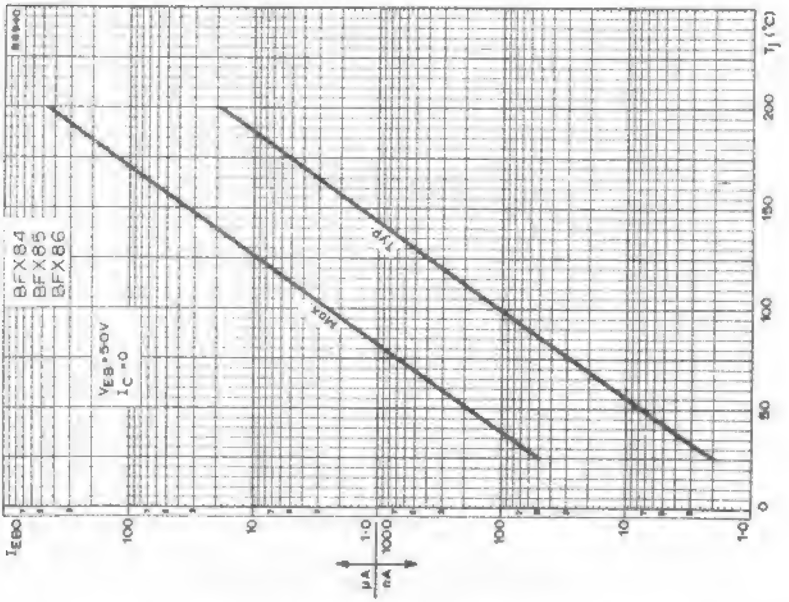


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

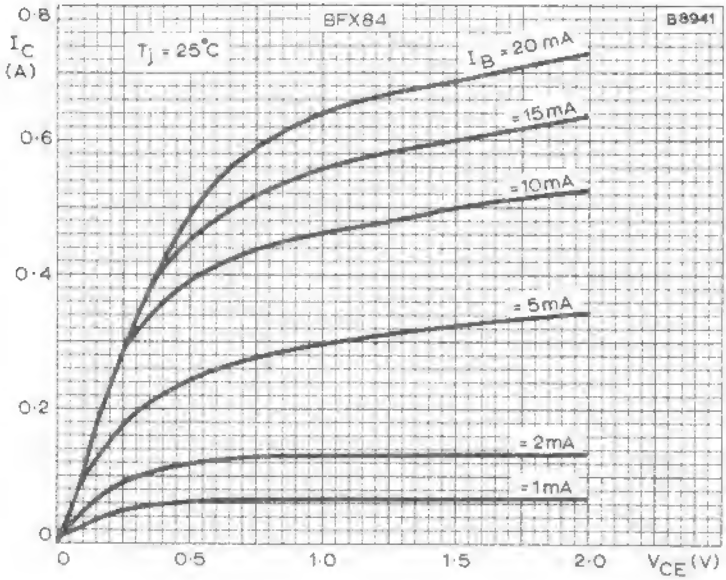


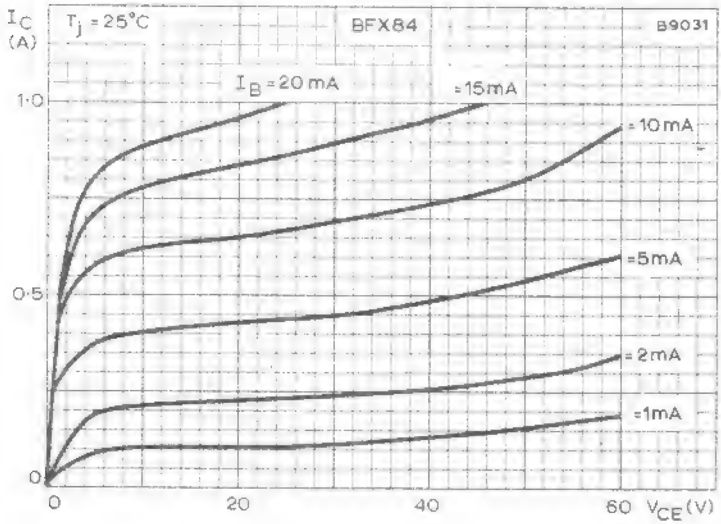
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION



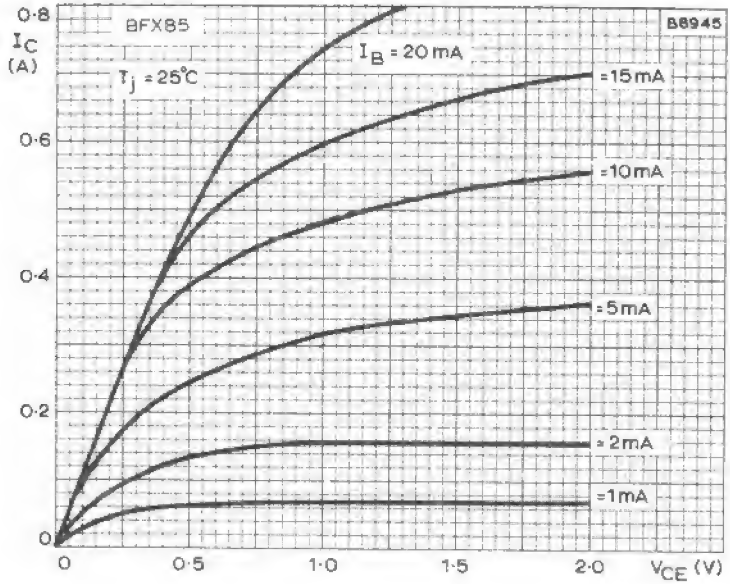


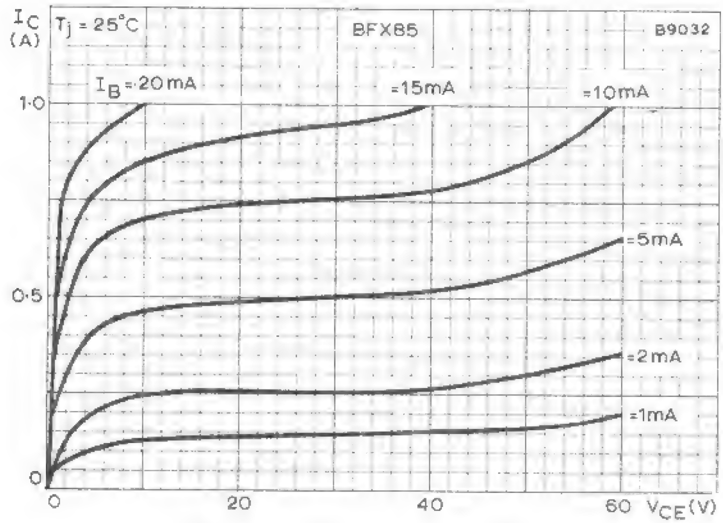
COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED
AGAINST JUNCTION TEMPERATURE



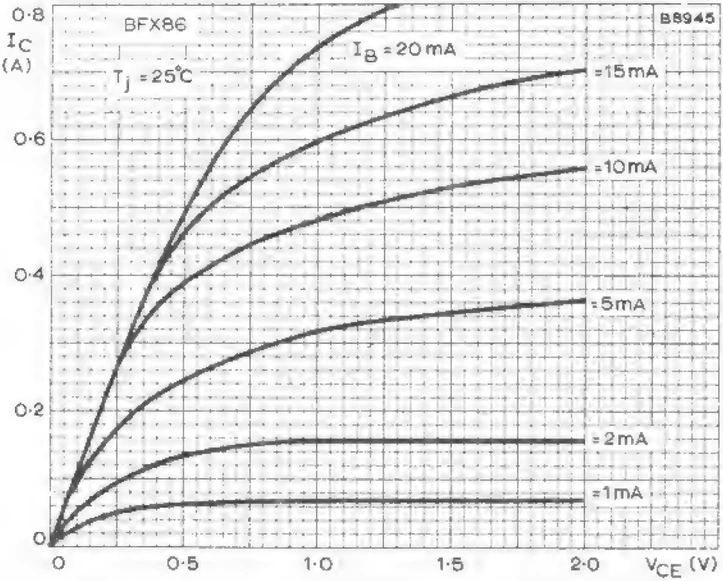


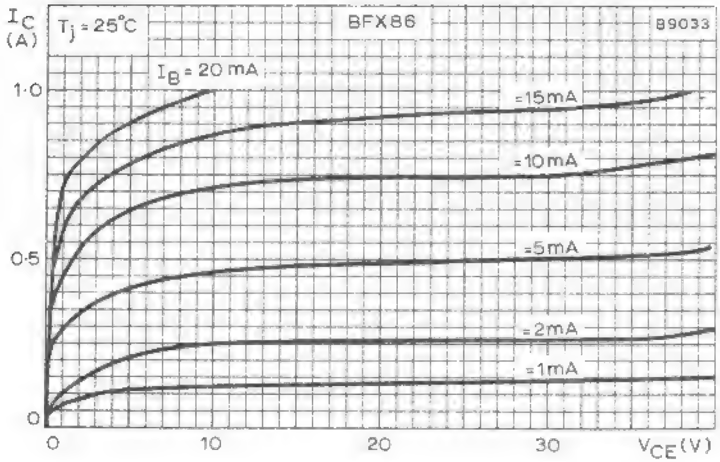
TYPICAL OUTPUT CHARACTERISTICS



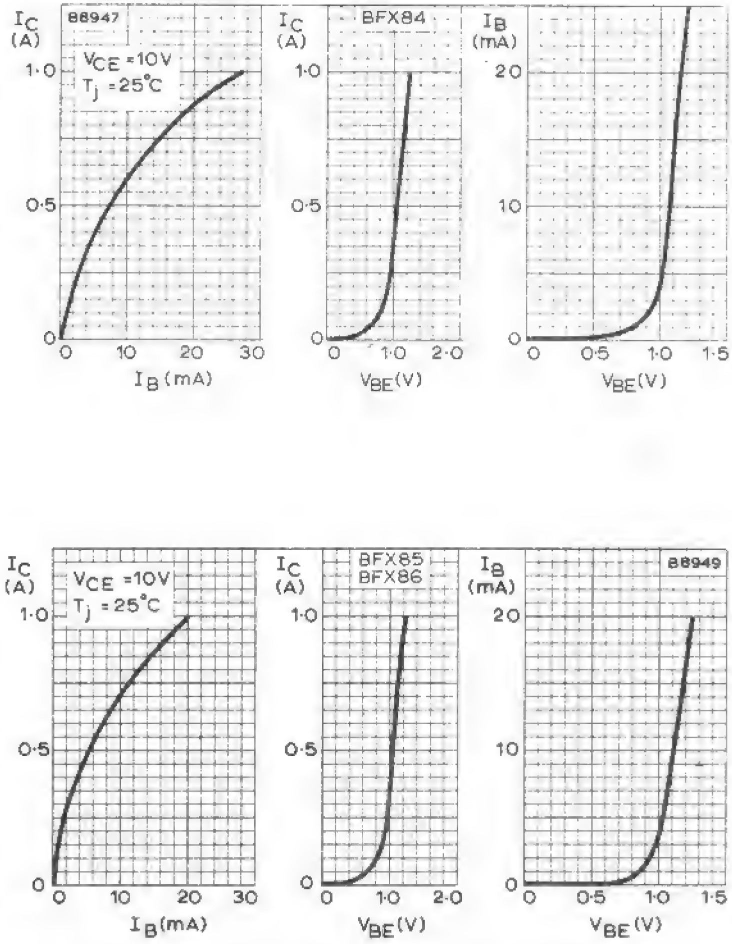


TYPICAL OUTPUT CHARACTERISTICS

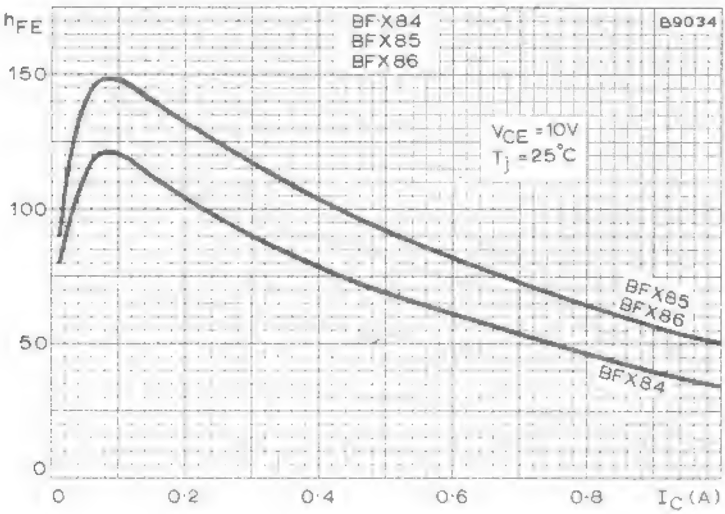


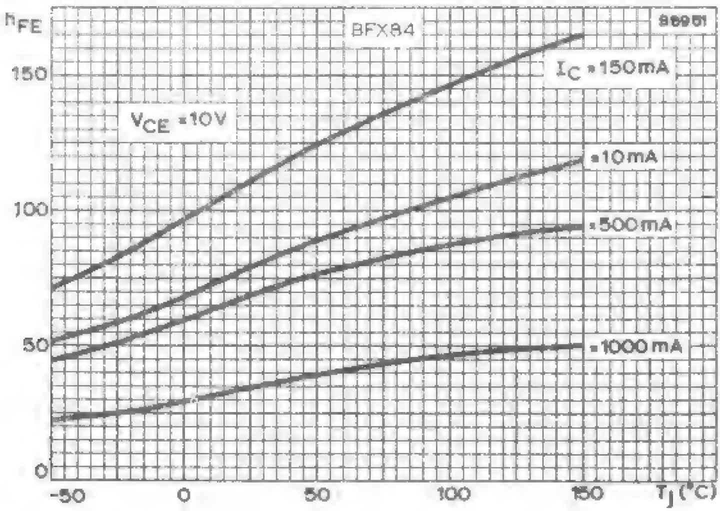


TYPICAL OUTPUT CHARACTERISTICS

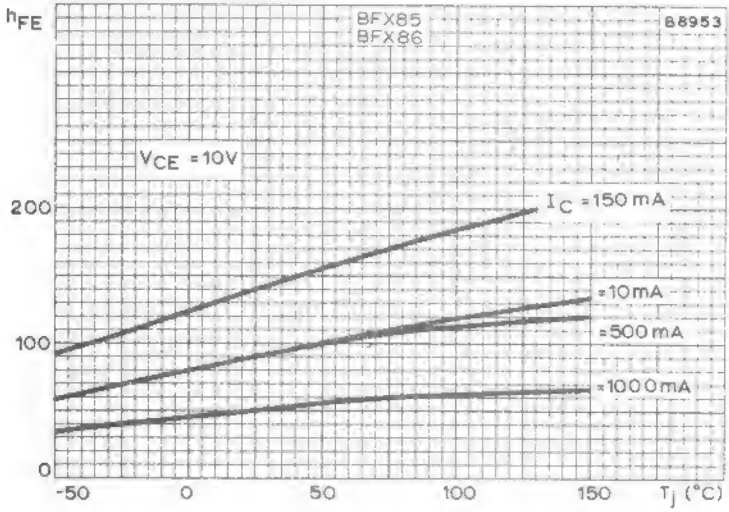


TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS

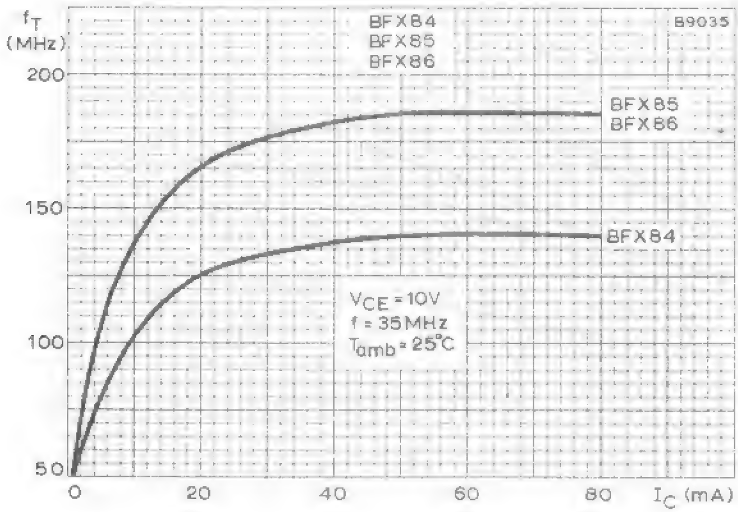




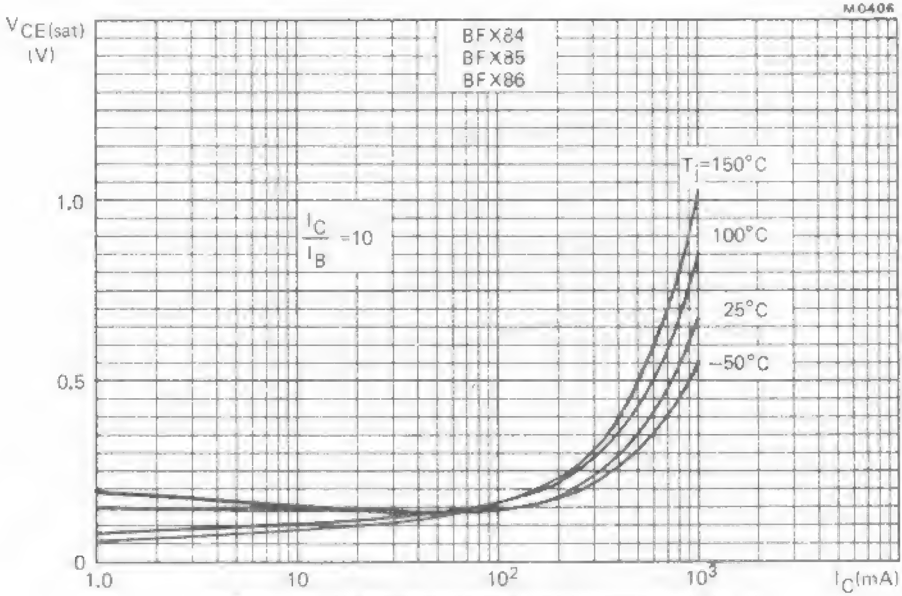
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE



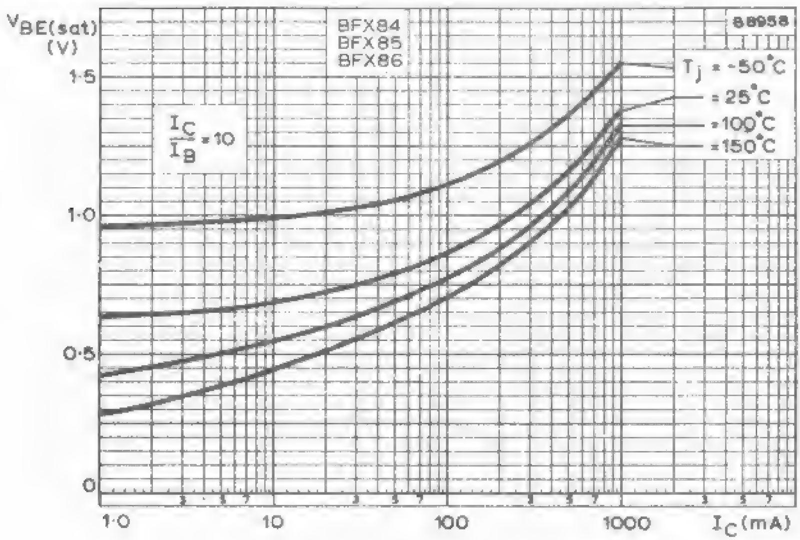
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



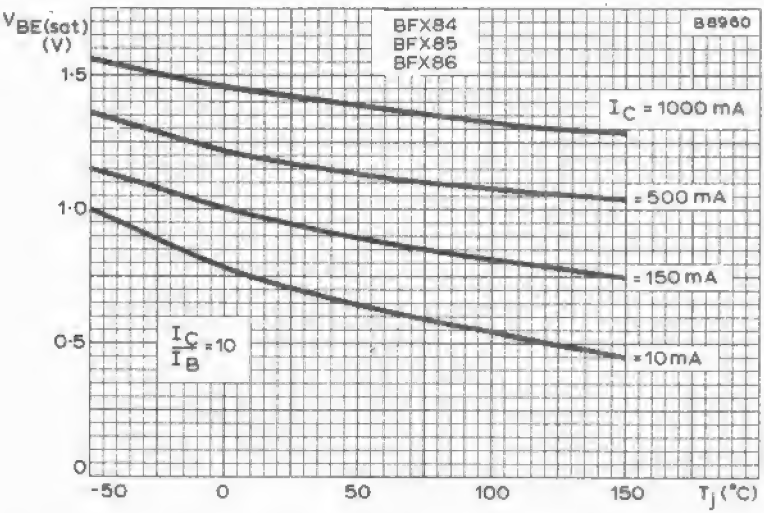
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



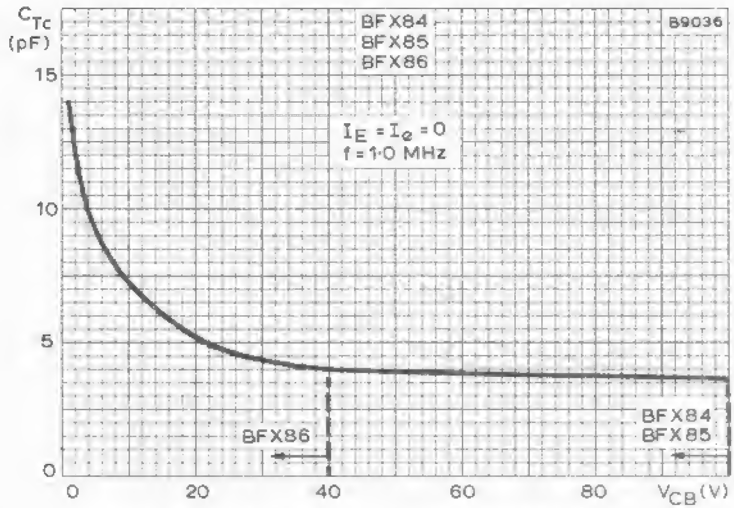
TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



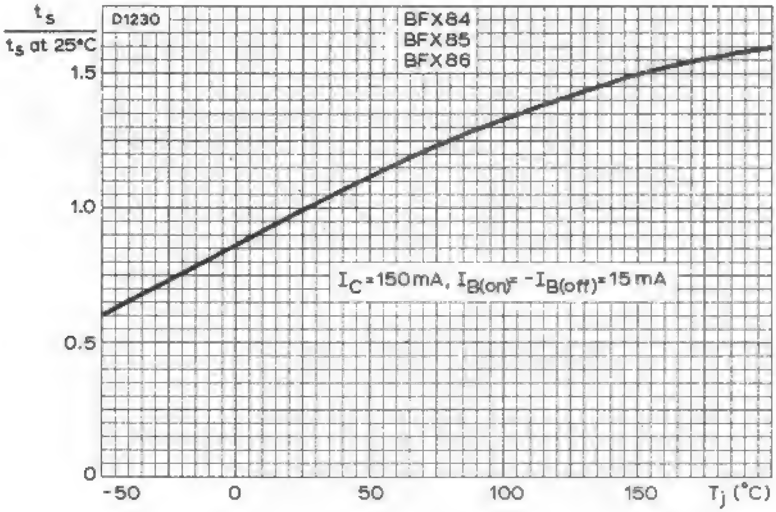
TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



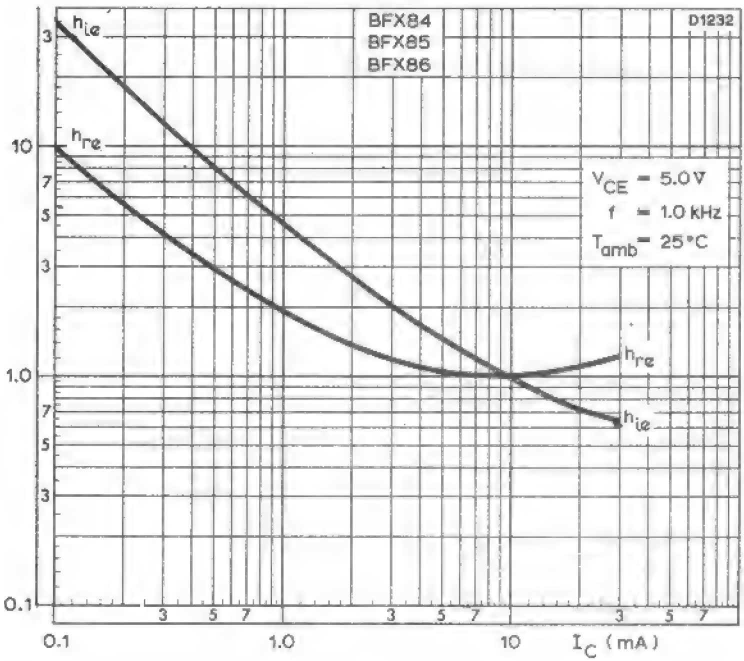
TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST JUNCTION TEMPERATURE

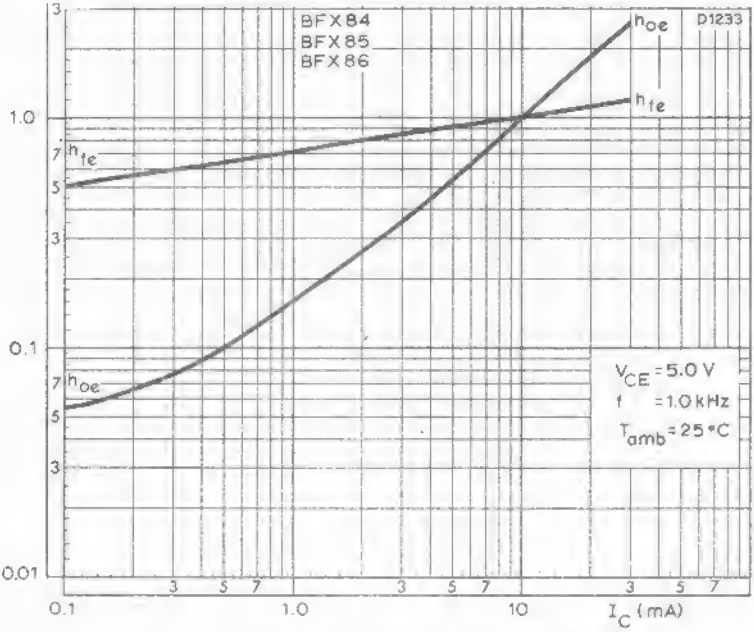


TYPICAL COLLECTOR CAPACITANCE PLOTTED AGAINST
COLLECTOR-BASE VOLTAGE



TYPICAL STORAGE TIME NORMALISED AT 25°C





TYPICAL h-PARAMETERS NORMALISED AT $I_C = 10mA$

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

For data of these transistors please refer to type BFX29.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes intended for general purpose industrial applications.

QUICK REFERENCE DATA

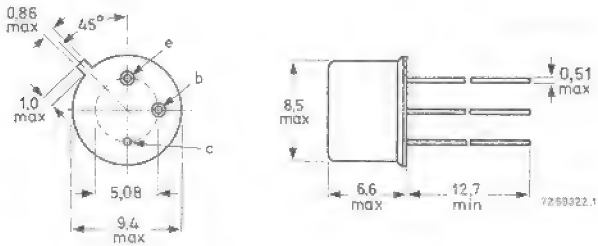
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
Total power dissipation up to T_{case} = 100 °C	P_{tot}	max.	2,86	2,86	2,86	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	30	40	60	
		typ.	112	123	142	
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 10 V; T_{amb} = 25 °C	f_T	>	60	50	50	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-089, available on request.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BFY50	BFY51	BFY52	
V_{CBO} max.	80	60	40	V
V_{CE} max. (cut-off, $I_C \leq 1mA$)	80	60	40	V
V_{CEO} max.	35	30	20	V
V_{EBO} max.		6.0		V
I_C max.		1.0		A
I_{CM} max.		1.0		A
$-I_E$ max.		1.0		A
$-I_{EM}$ max.		1.0		A
I_B max.		100		mA
$\pm I_{BM}$ max.		100		mA
P_{tot} max. $T_{amb} \leq 25^oC$		800		mW
$T_{case} \leq 25^oC$		5.0		W
$T_{case} > 25, < 100^oC$		2.86		W

Temperature

T_{stg}	-65 to +200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

BFY50

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 80V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 60V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 60V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	20	80	-	
	$I_C = 150mA$, $V_{CE} = 10V$	30	112	-	
	$I_C = 500mA$, $V_{CE} = 10V$	20	70	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.20	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	0.70	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

BFY50

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	60	140	-	MHz

Saturated switching times

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$;
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		Min.	Typ.	Max.	
t_d	Delay time	-	15	-	ns
t_r	Rise time	-	40	-	ns
t_{on}	Turn-on time	-	55	-	ns
t_s	Storage time	-	300	-	ns
t_f	Fall time	-	60	-	ns
t_{off}	Turn-off time	-	360	-	ns

h-parameters

		Min.	Typ.	Max.	
h_{fe}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	10	65	-	-
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	750	-	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		15	80	-	
h_{oe}		-	35	80	μmho

BFY51

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 60V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 60V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 40V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	30	85	-	
	$I_C = 150mA$, $V_{CE} = 10V$	40	123	-	
	$I_C = 500mA$, $V_{CE} = 10V$	25	79	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	40	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	7.0	12	pF

BFY51/BFY52

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	-	-	MHz

Saturated switching times

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$,
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		Min.	Typ.	Max.	
t_d	Delay time	-	15	-	ns
t_r	Rise time	-	40	-	ns
t_{on}	Turn-on time	-	55	-	ns
t_s	Storage time	-	300	-	ns
t_f	Fall time	-	60	-	ns
t_{off}	Turn-off time	-	360	-	ns

h-parameters

		Min.	Typ.	Max.	
h_{fe}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	20	65	-	-
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	750	-	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		25	80	-	
h_{oe}		-	35	80	μmho

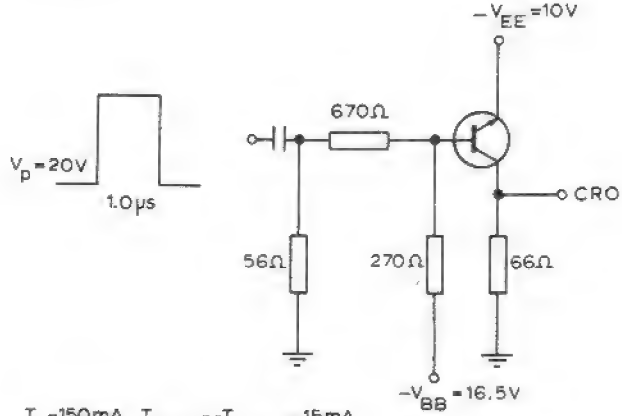
BFY52

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 40V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 30V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 30V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 150mA$, $V_{CE} = 10V$	60	142	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.15	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance $V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

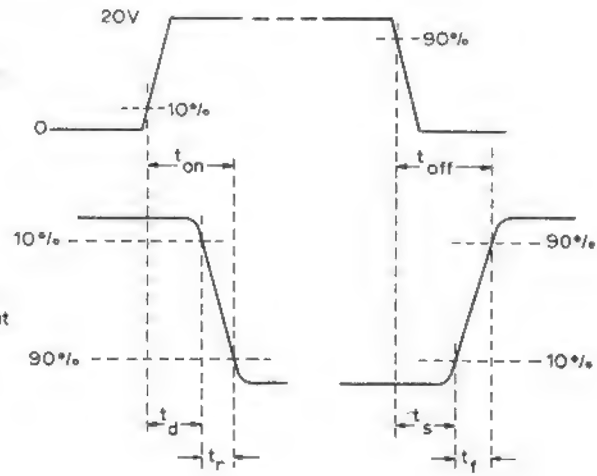
MEASUREMENT OF SATURATED SWITCHING TIMES

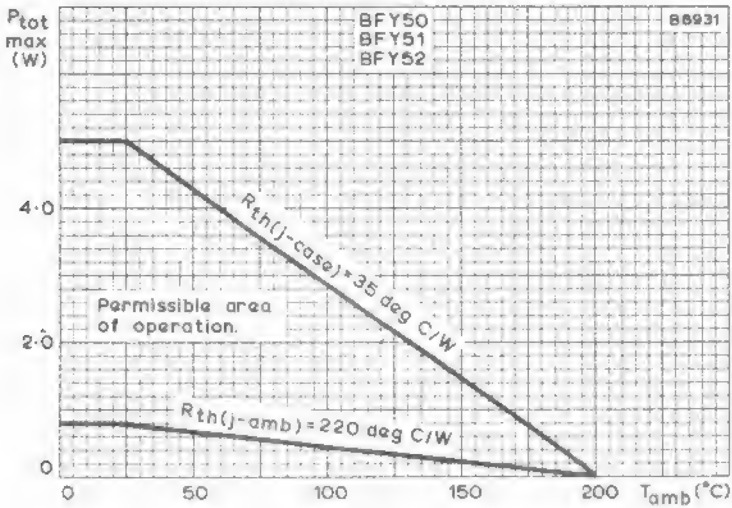
Test circuit



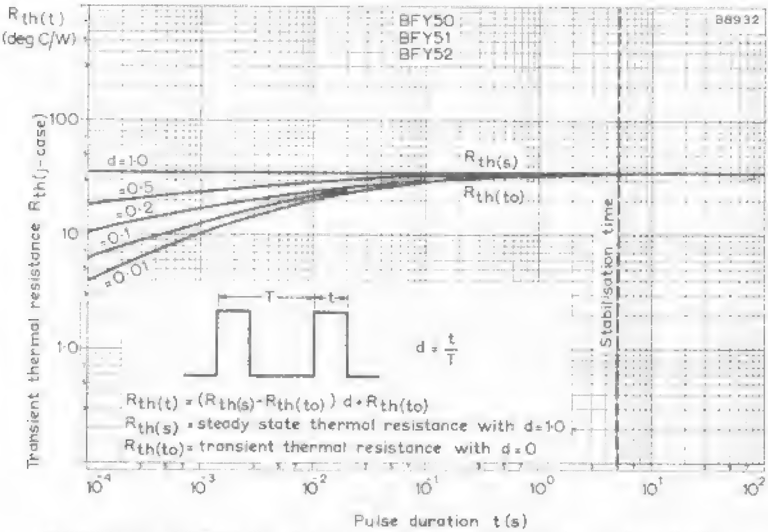
I_C = 150mA, $I_{B(on)} = -I_{B(off)}$ = 15mA
$-V_{BE(off)}$ = 2.0 V

Switching waveforms

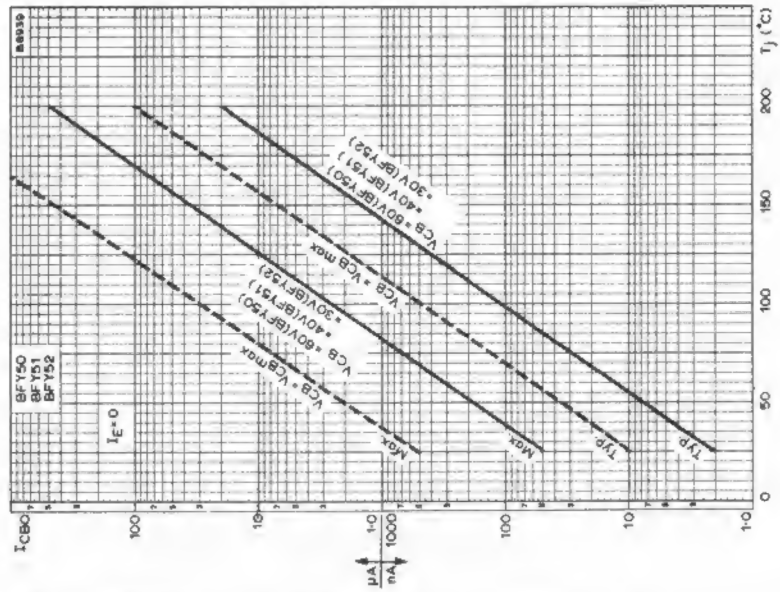


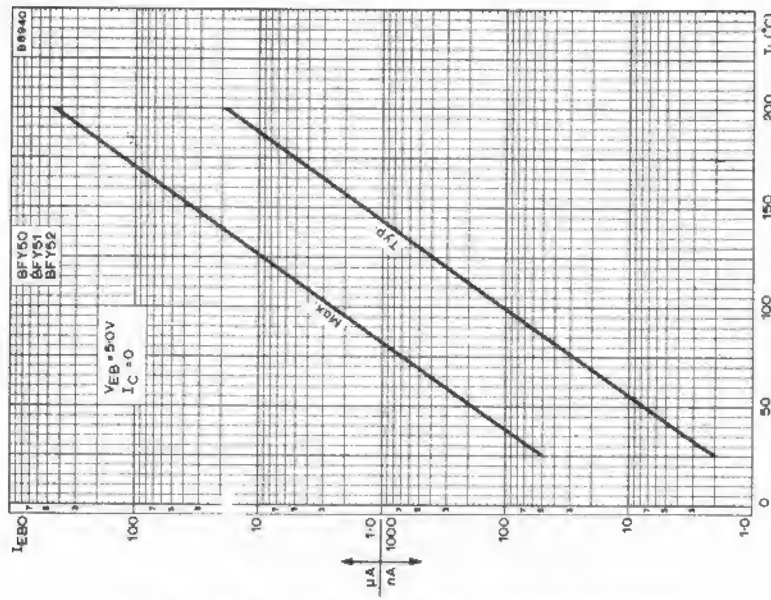


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

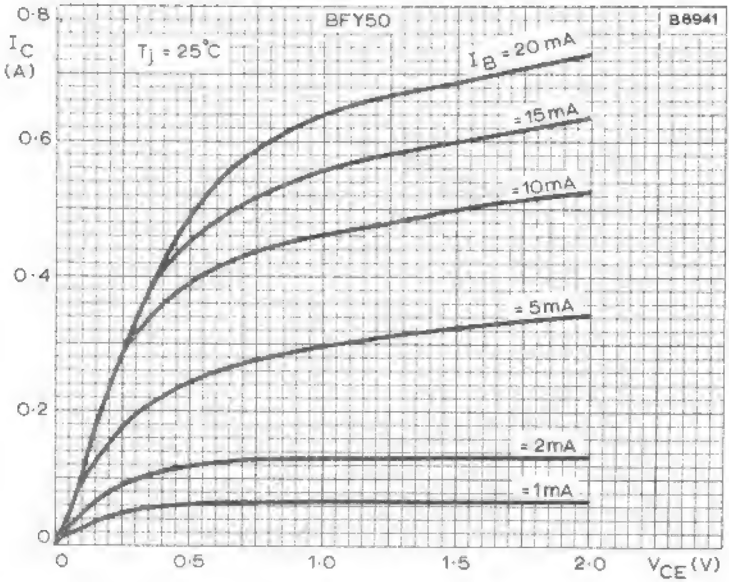


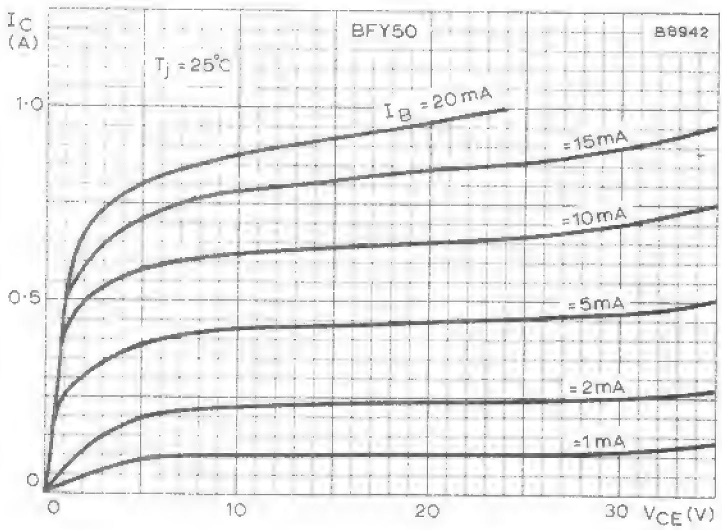
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION



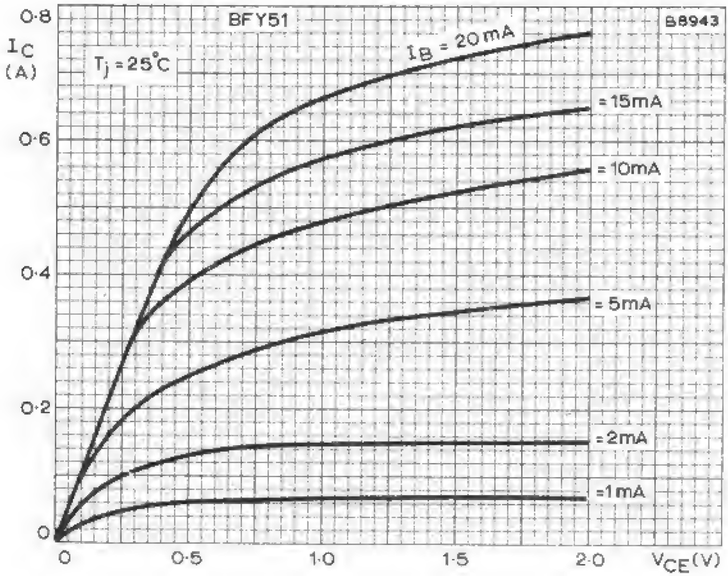


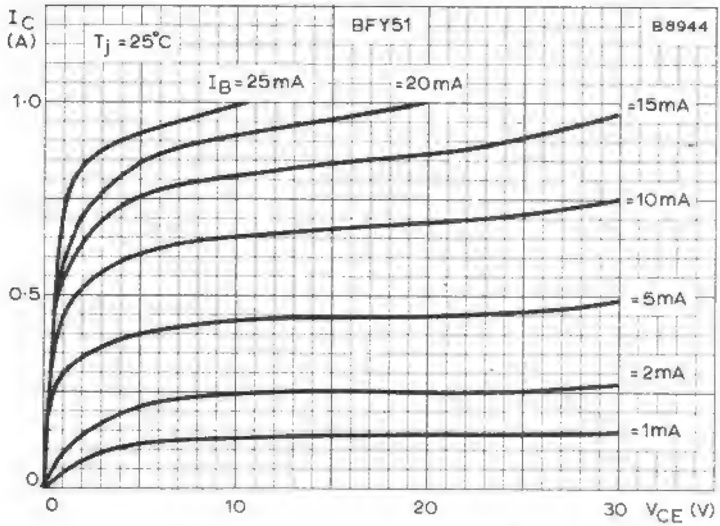
COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED
AGAINST JUNCTION TEMPERATURE



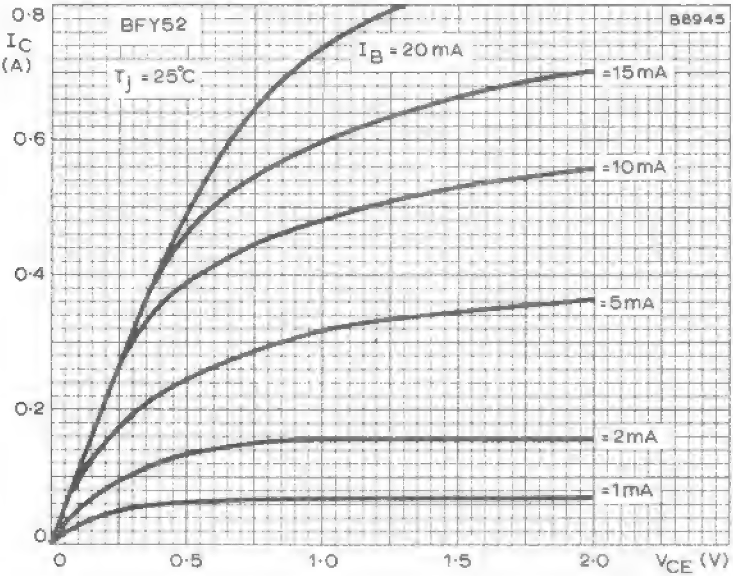


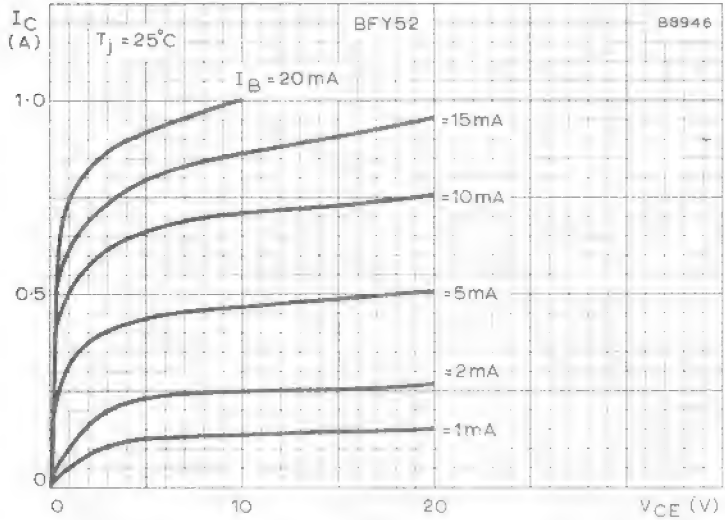
TYPICAL OUTPUT CHARACTERISTICS



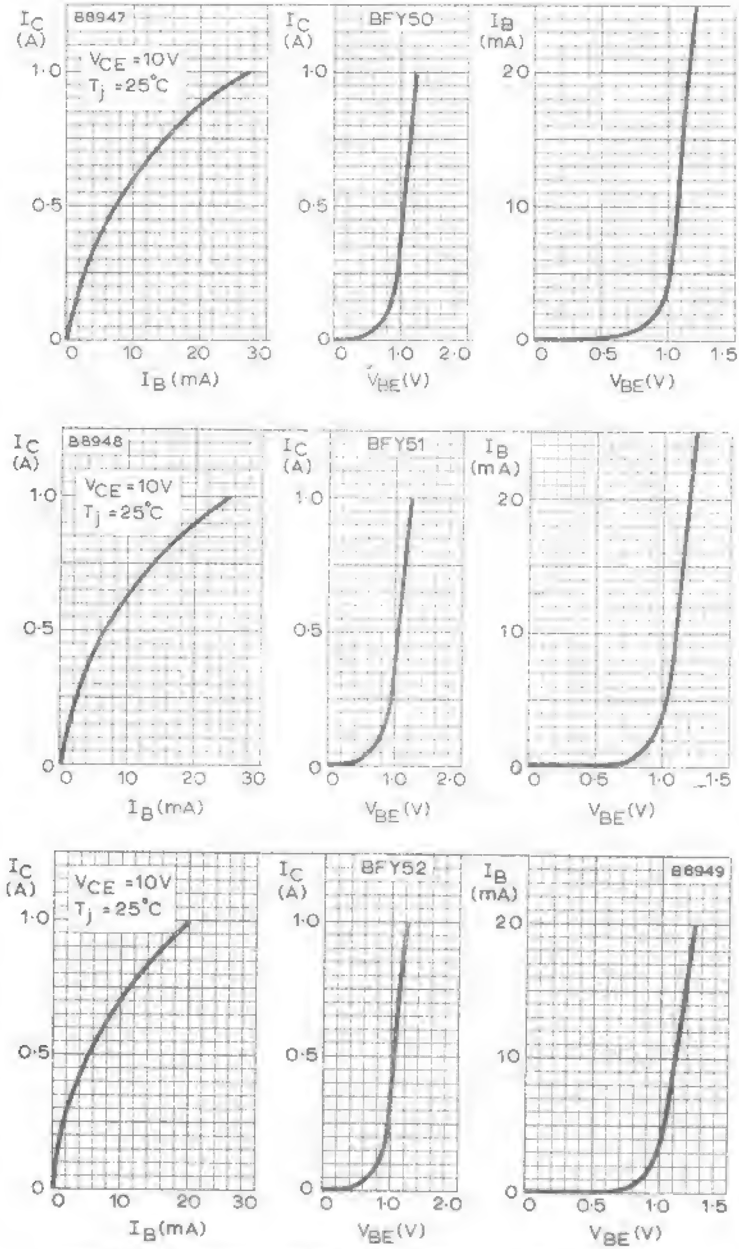


TYPICAL OUTPUT CHARACTERISTICS

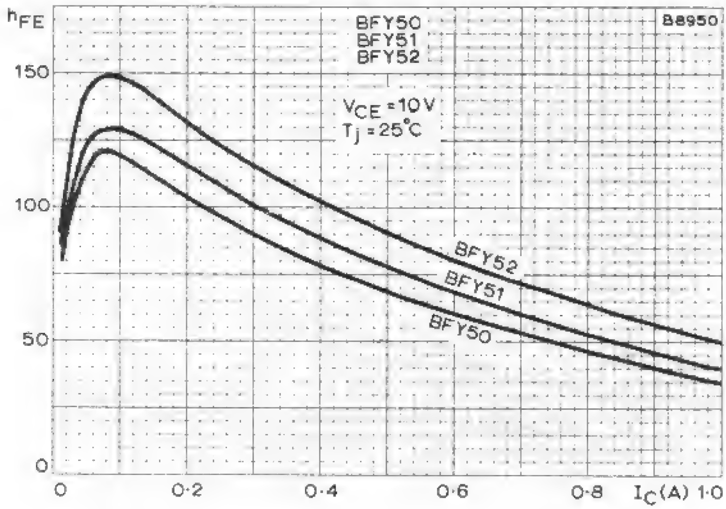


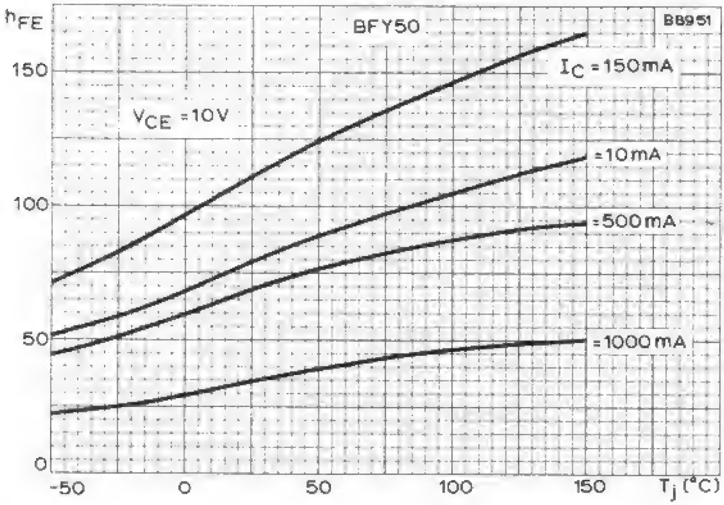


TYPICAL OUTPUT CHARACTERISTICS

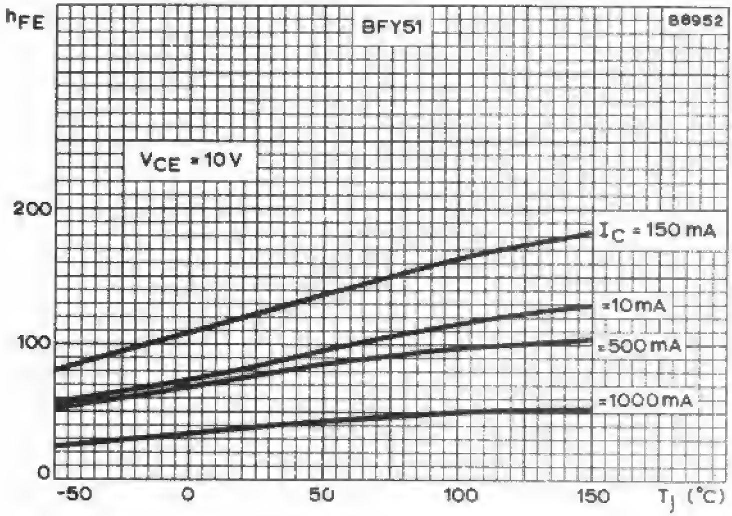


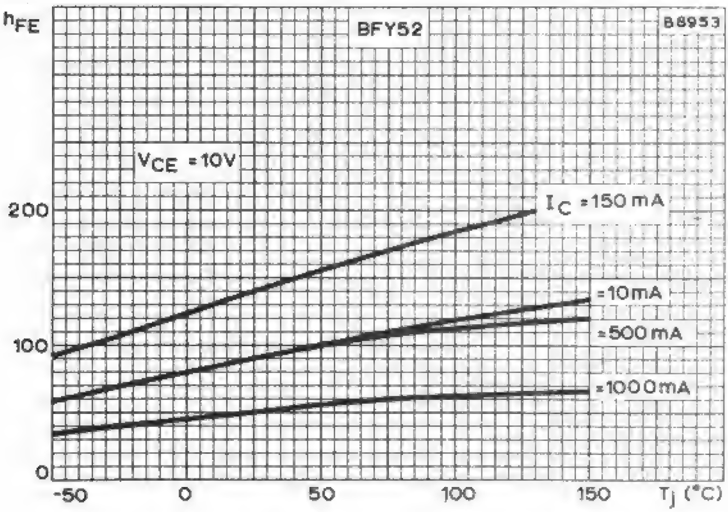
TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS



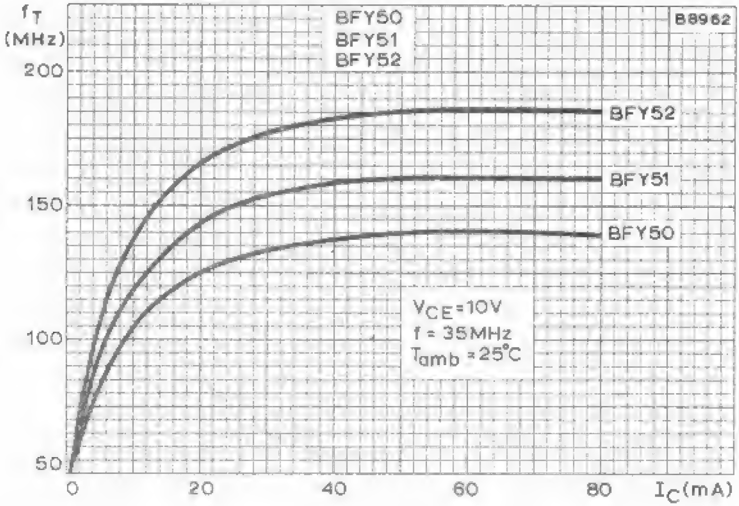


TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE

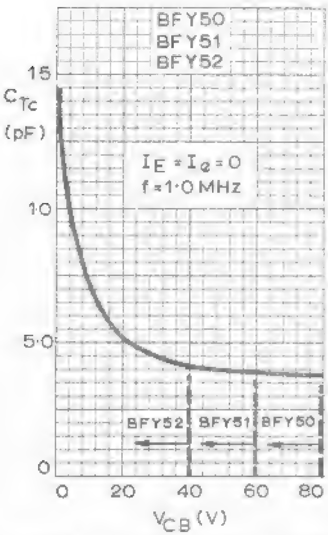




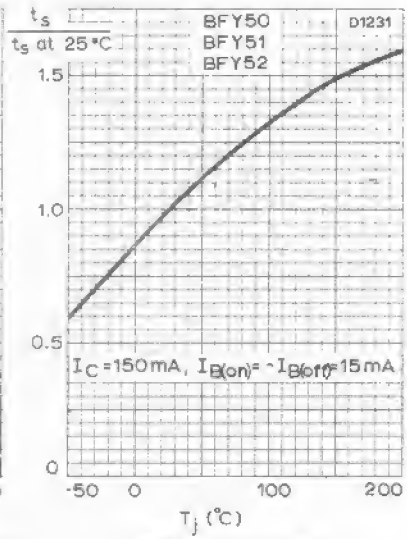
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



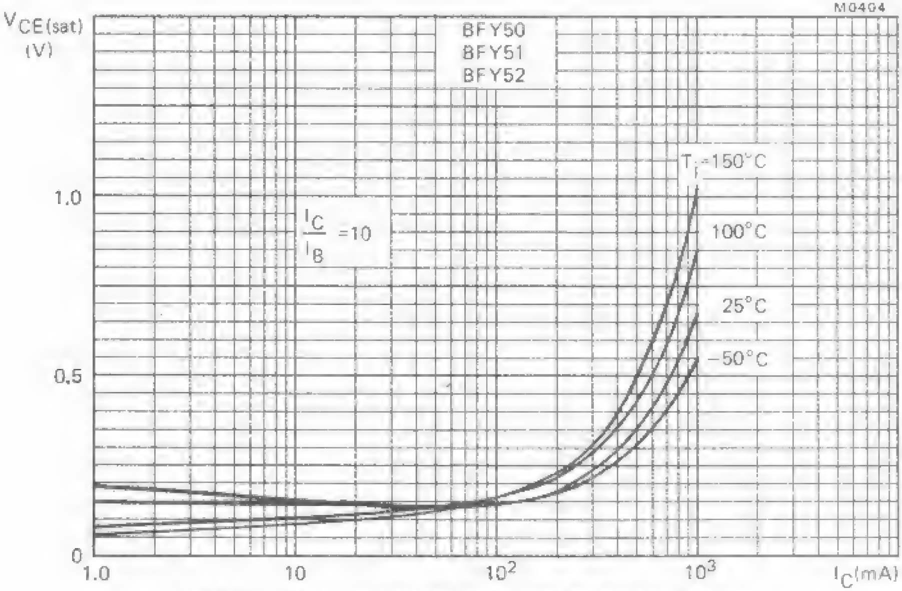
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



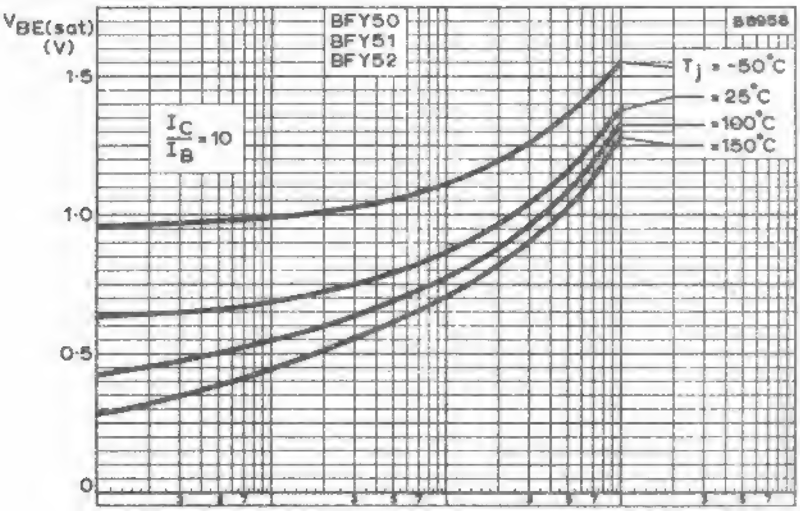
Typical collector capacitance versus collector-base voltage



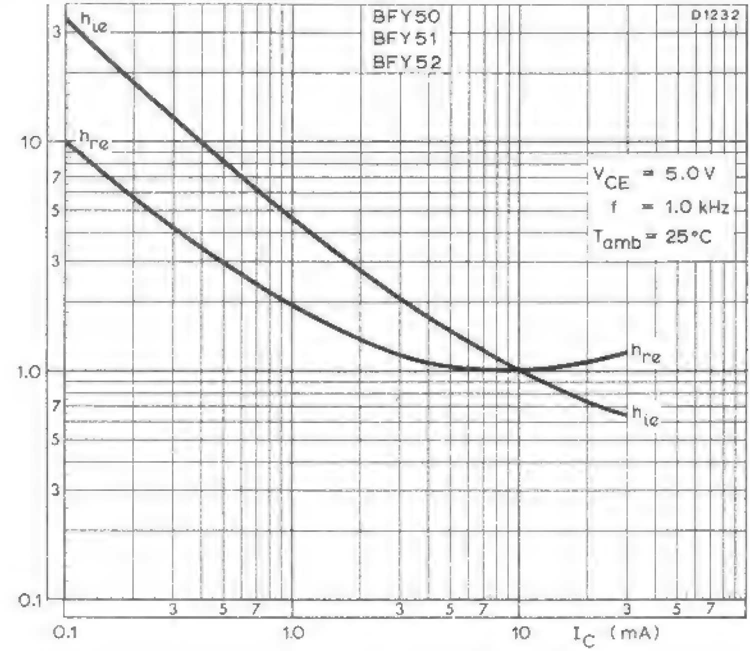
Typical storage time normalised at 25°C

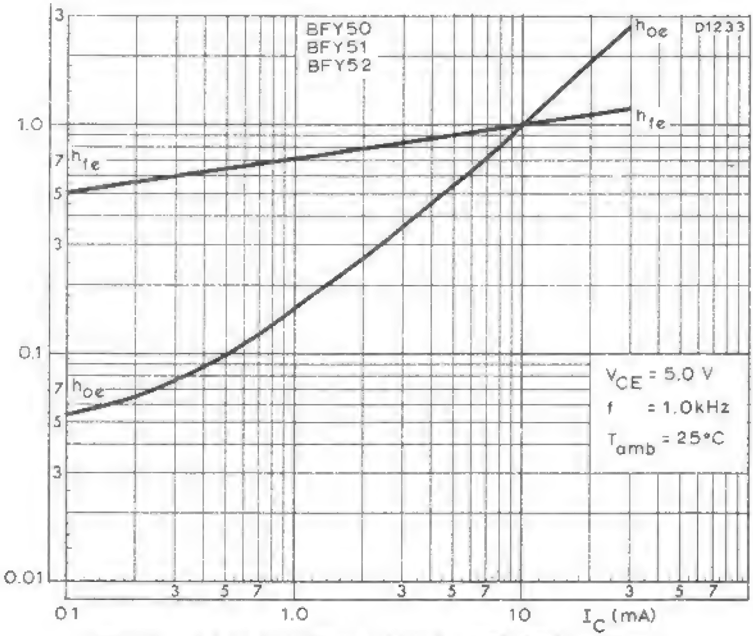


TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT





TYPICAL h-PARAMETERS NORMALIZED AT I_C = 10 mA

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-39 metal case with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

QUICK REFERENCE DATA

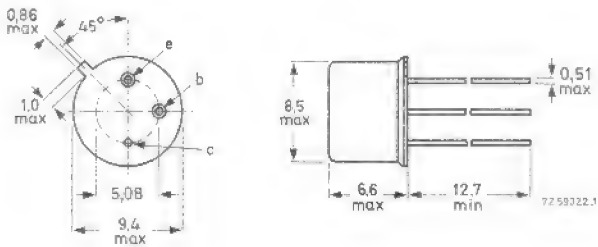
Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	40	
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz
Collector-emitter saturation voltage I_C = 1 A; I_B = 100 mA	V_{CEsat}	<	1	V

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	1	A
Emitter current (peak value)	$-I_{EM}$	max.	1	A

Power dissipation (See also page 4)

Total power dissipation up to T_{amb} = 40 °C	P_{tot}	max.	4	W
Total power dissipation without cooling fin up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W

Temperatures

Storage temperature	T_{stg}	−65 to +200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.22	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.035	°C/mW

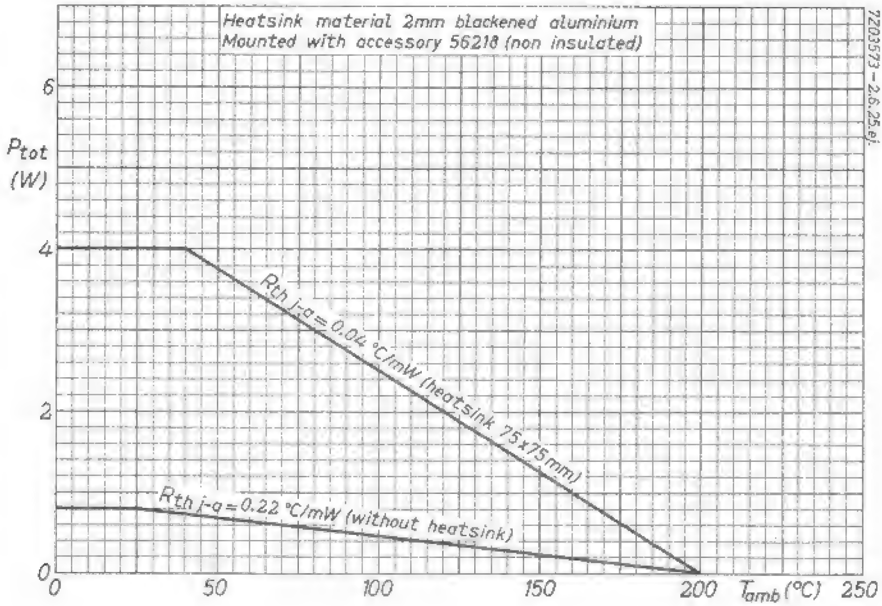
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

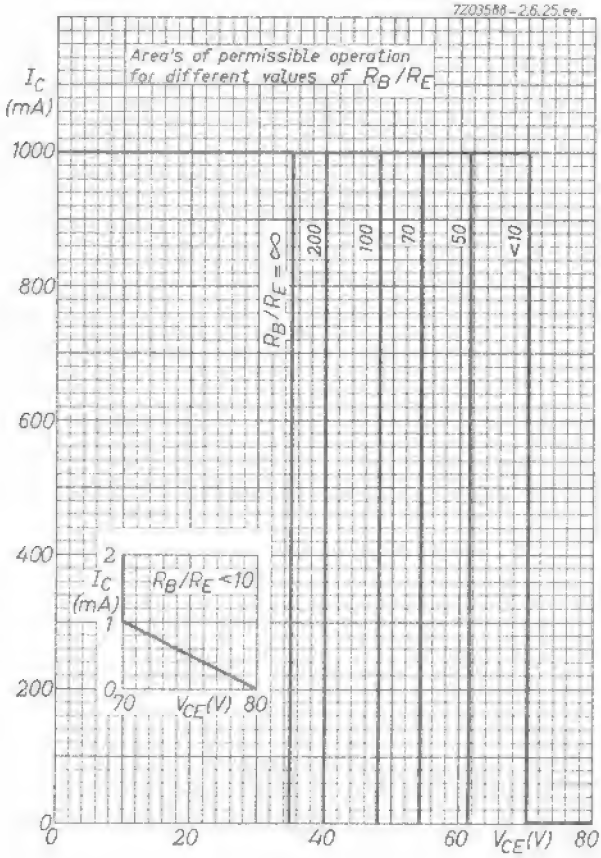
CHARACTERISTICS — $T_j = 25\ ^{o}C$ unless otherwise specified

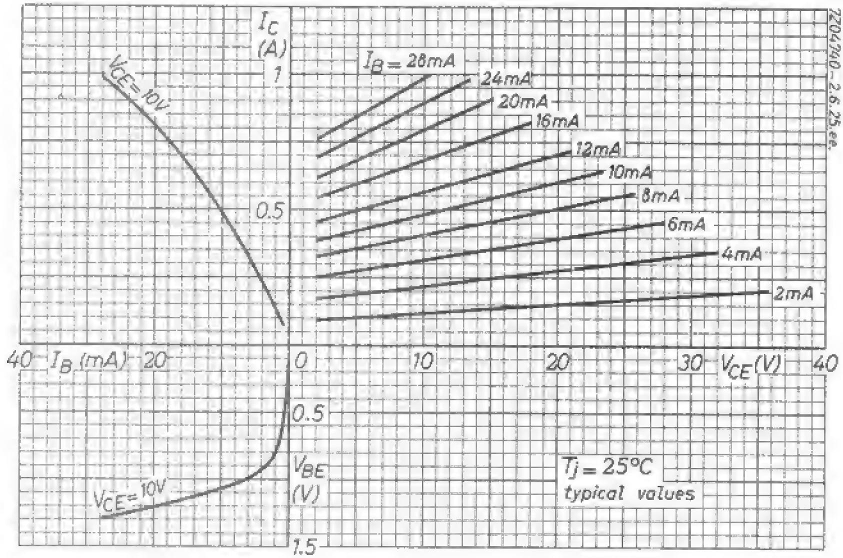
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150\ ^{o}C$	I_{CBO}	<	10	µA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA [1][2]	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.6	V
Sustaining voltage				
$I_C = 30$ mA; $I_B = 0$ [2]	$V_{CEOsust}$	>	35	V
D.C. current gain [2]				
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120	
$I_C = 1$ A; $V_{CE} = 10$ V	h_{FE}	>	15	
Feedback time constant				
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4 MHz	$r_b' C_c$	<	800	ps
Collector capacitance at f = 500 kHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12	pF
Emitter capacitance at f = 500 kHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	80	pF
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

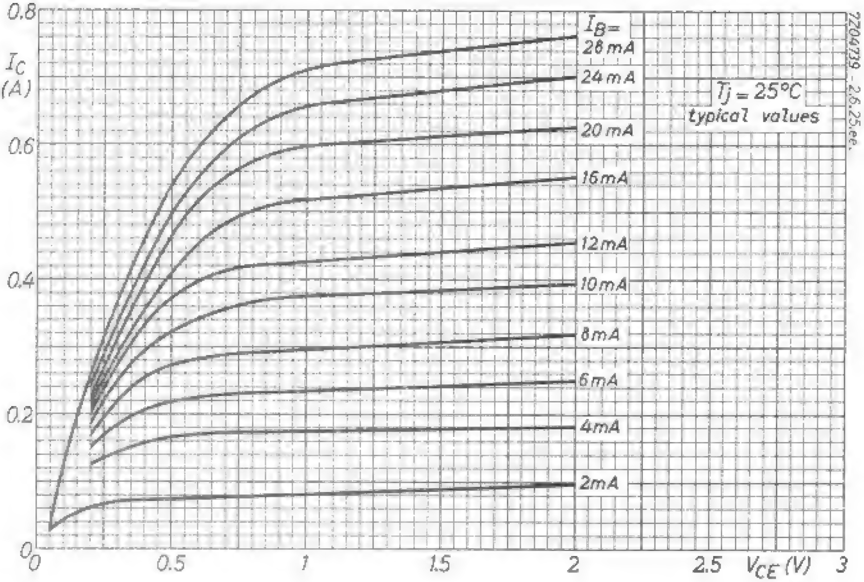
[1]) Measured with a lead length of 1 cm.

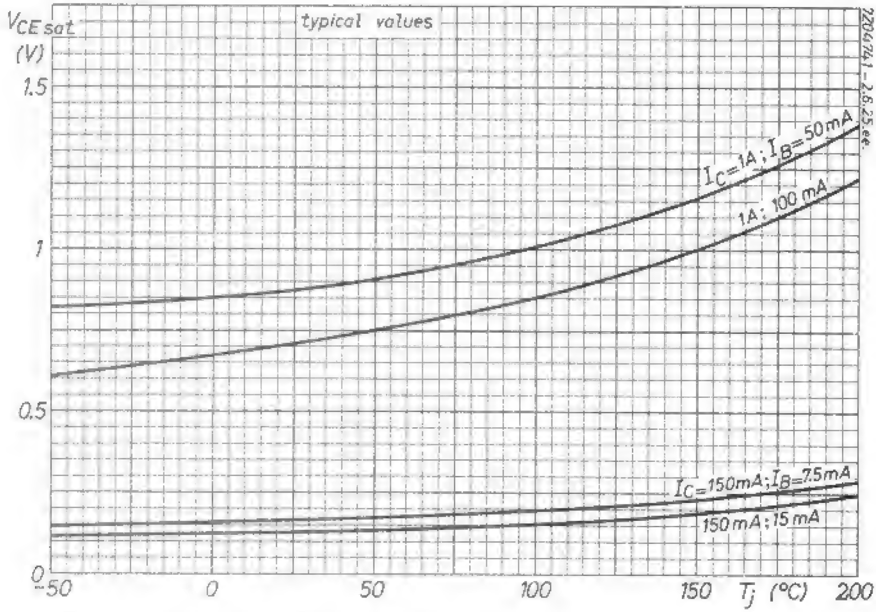
[2]) Measured under pulsed conditions to avoid excessive dissipation. Pulse duration = 300 µs; duty cycle $\delta < 0.01$

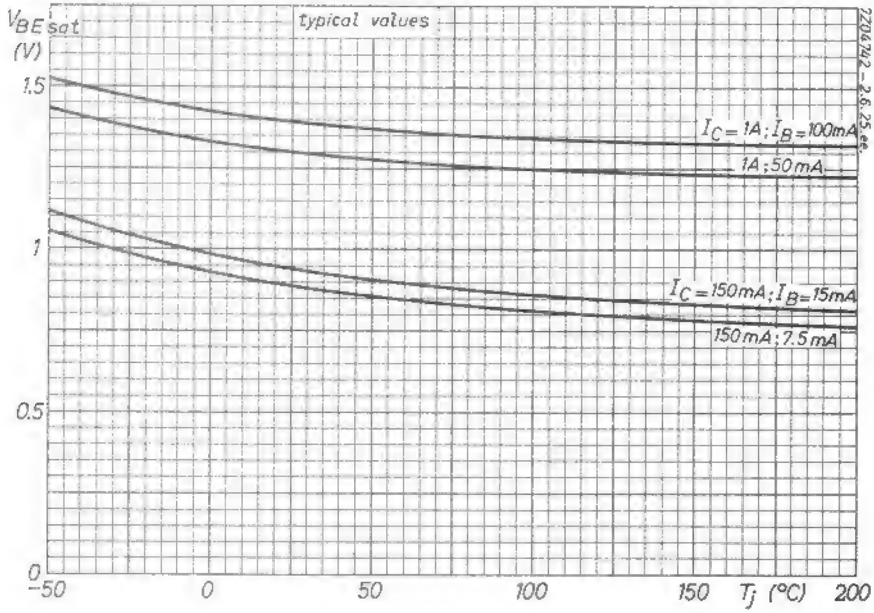

Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573 - 2.6.25.ej.
Ptot
(W)
6
4
2
0
Rth j-a = 0.04 °C/mW (heatsink 75x75mm)
Rth j-a = 0.22 °C/mW (without heatsink)
0
50
100
150
200
Tamb (°C)
250

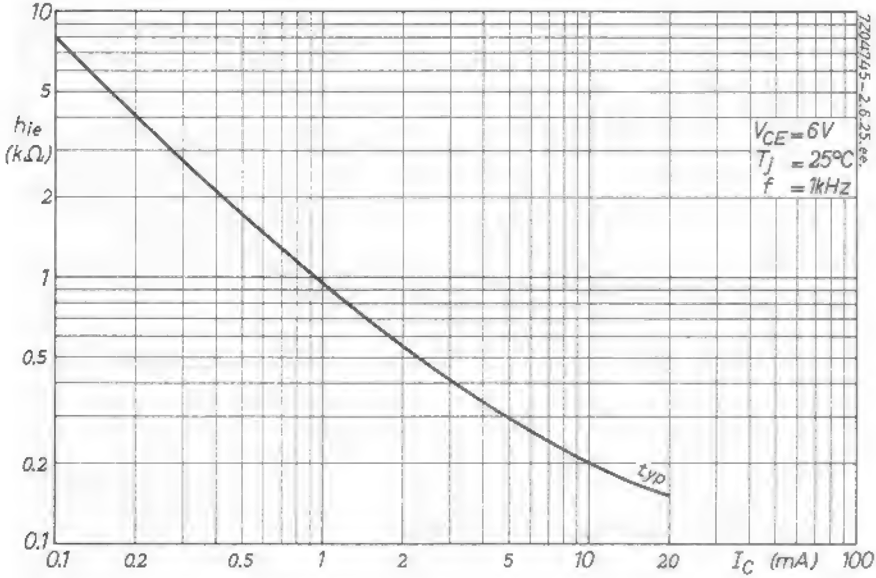

7Z03588-2.6.25.ee.
Area's of permissible operation
for different values of R_B/R_E
I_C (mA)
1000
800
600
400
200
0
0
20
40
60
V_{CE}(V)
80
$R_B/R_E = \infty$
200
100
70
50
<10
2
I_C (mA)
R_B/R_E <10
1
0
70
V_{CE}(V)
80

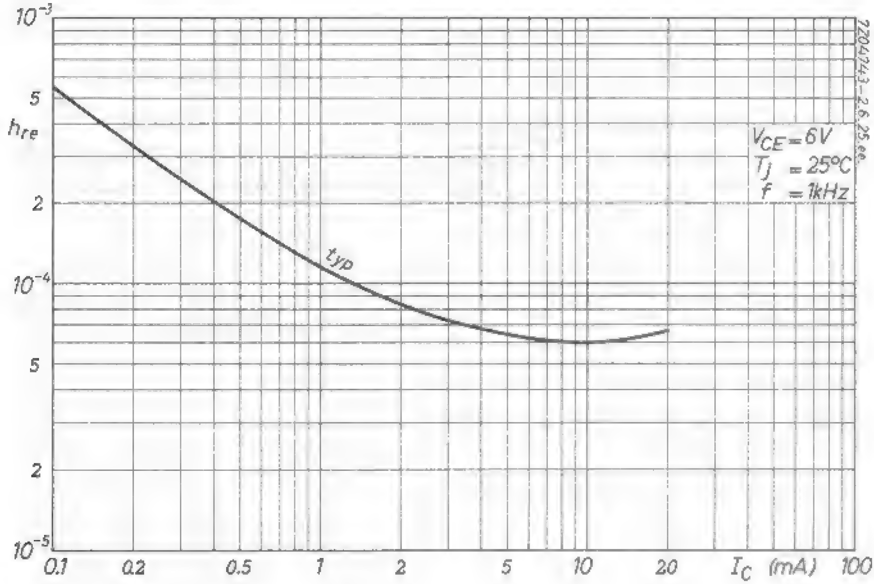

7204740 - 2.6.25.ee.
I_C (A)
1
0.5
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
V_{CE} = 10V
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values

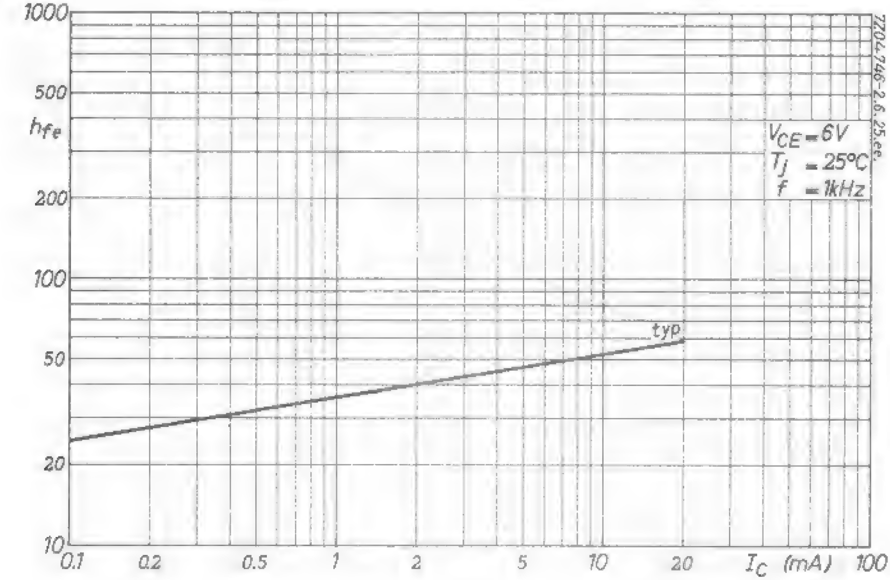

7204739 - 2.6.25.ee.
0.8
I_C (A)
0.6
0.4
0.2
0
I_B = 28 mA
24 mA
20 mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3

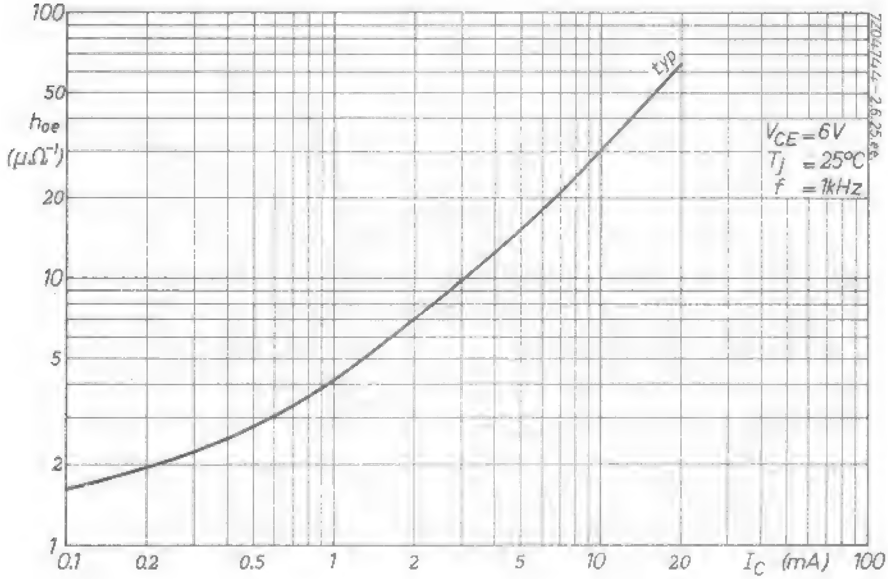

V_{CEsat}
(V)
typical values
7Z04741 - 2.6.25.ee.
1.5
1
0.5
0
I_C=1A ; I_B=50mA
1A ; 100 mA
I_C=150mA ; I_B=7.5mA
150 mA ; 15 mA
-50
0
50
100
150
T_j (°C)
200

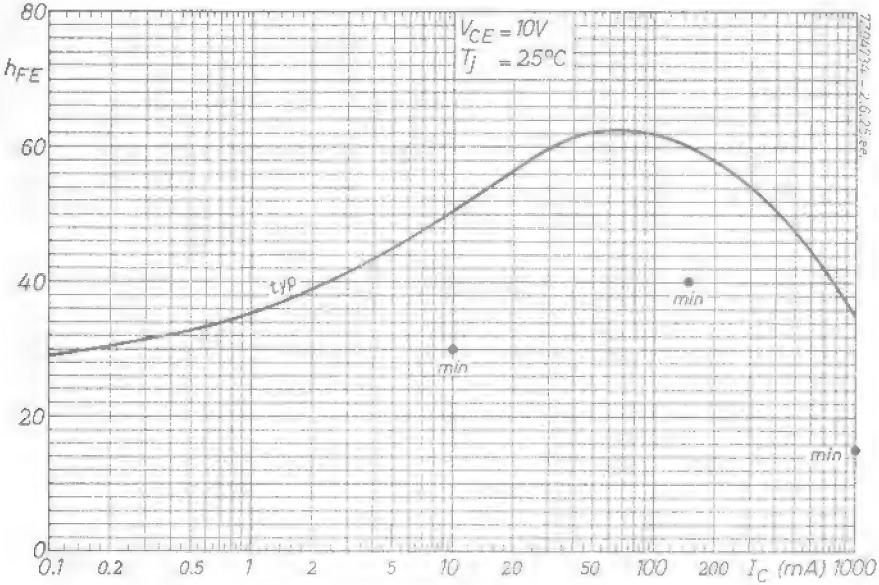

V_{BEsat}
(V)
typical values
7Z04742 - 2.6.25.ee.
1.5
1
0.5
0
I_C = 1A ; I_B = 100mA
1A ; 50mA
I_C = 150mA ; I_B = 15mA
150mA ; 7.5mA
-50
0
50
100
150
T_j (°C)
200

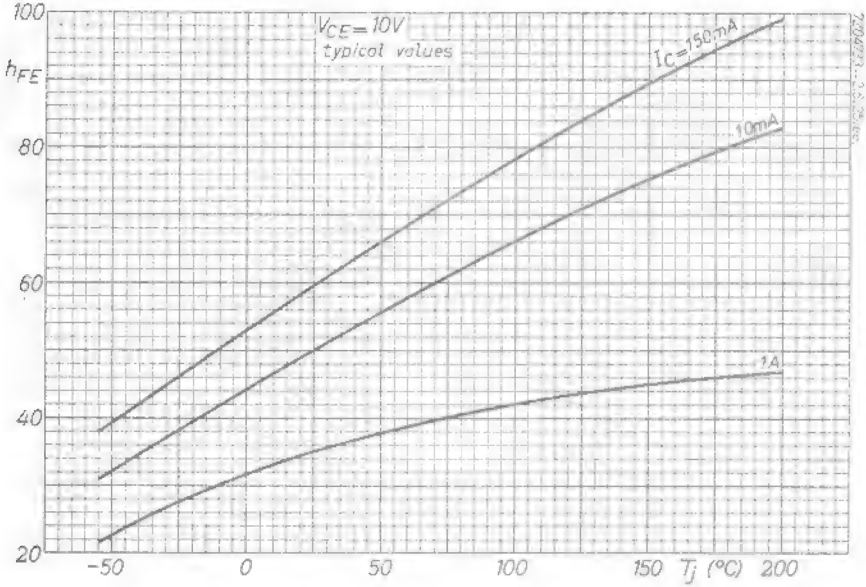

7204745-2.6.25.ee.
10
5
h_{ie}
$(k\Omega)$
2
1
0.5
0.2
0.1
$V_{CE} = 6V$
$T_j = 25°C$
$f = 1kHz$
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

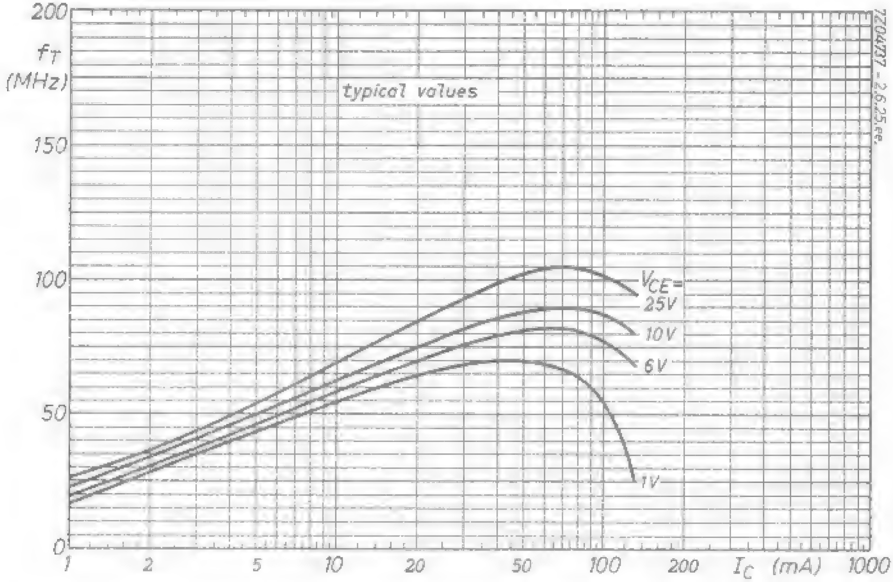

7204743-2.6.25.ee.
10^{-3}
5
h_{re}
2
10^{-4}
5
2
10^{-5}
$V_{CE} = 6V$
$T_j = 25°C$
$f = 1kHz$
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

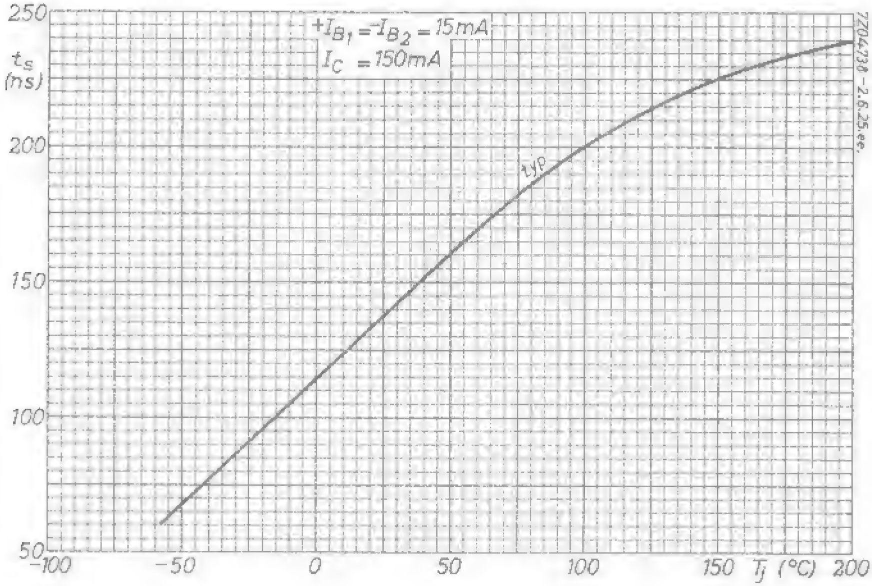

1000
500
h_{fe}
200
100
50
20
10
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04746-2.6.25.ee.

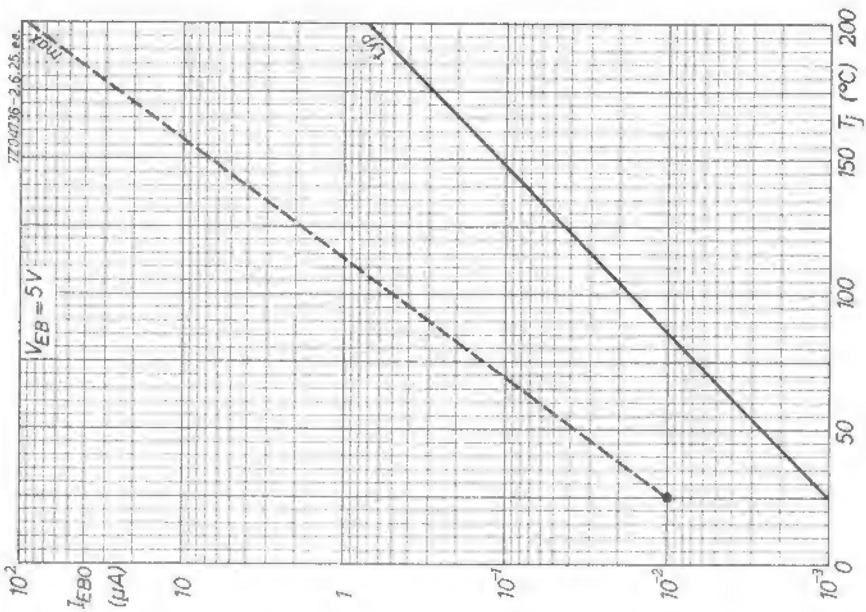

100
50
h_{oe}
($\mu\Omega^{-1}$)
20
10
5
2
1
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04744-2.6.25.ee.

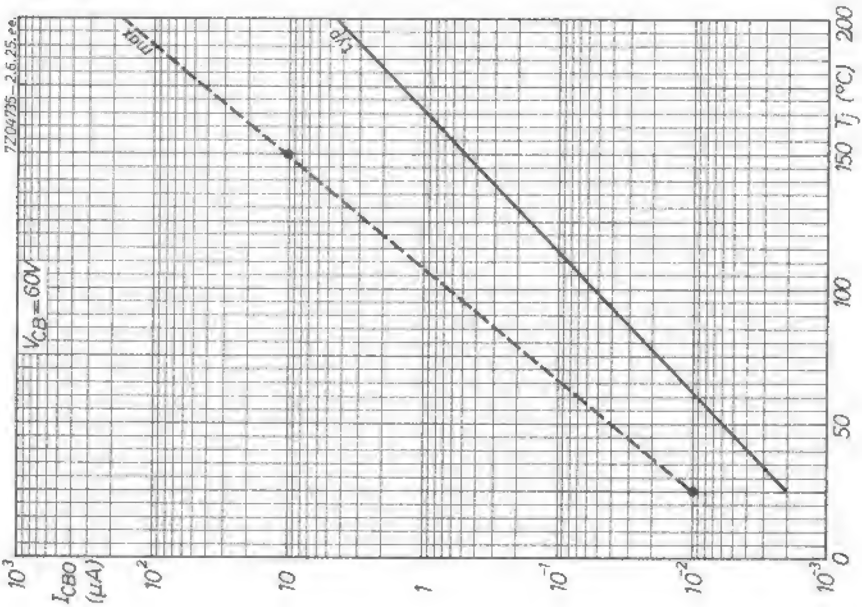

80
h_{FE}
60
40
20
0
$V_{CE} = 10V$
$T_j = 25°C$
typ
min
min
min
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_C (mA) 1000


100
h_{FE}
80
60
40
20
$V_{CE} = 10V$
typical values
$I_C = 150mA$
10mA
1A
−50
0
50
100
150
T_j (°C)
200


200
f_T
(MHz)
typical values
150
100
$V_{CE}=$
25V
10V
6V
50
1V
0
1
2
5
10
20
50
100
200
I_C (mA)
1000
7Z04737 - 2.6.25.ee.


250
t_s
(ns)
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
200
typ
150
100
50
−100
−50
0
50
100
150
T_j (°C)
200
7Z04738 - 2.6.25.ee.


7Z04736-2.6.25.ee.
V_EB = 5 V
max
typ
I_EBO (μA)
T_j (°C)
10^2
10
1
10^-1
10^-2
10^-3
0
50
100
150
200


7Z04735-2.6.25.ee.
V_CB = 60 V
max
typ
I_CBO (μA)
T_j (°C)
10^3
10^2
10
1
10^-1
10^-2
10^-3
0
50
100
150
200

SILICON CONTROLLED SWITCH

The BR101 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for time base circuits and other television applications. It is also suitable as trigger device for thyristors. It is an integrated p-n-p/n-p-n transistor pair of which all electrodes are accessible. The collector of the n-p-n transistor is connected to the case.

QUICK REFERENCE DATA

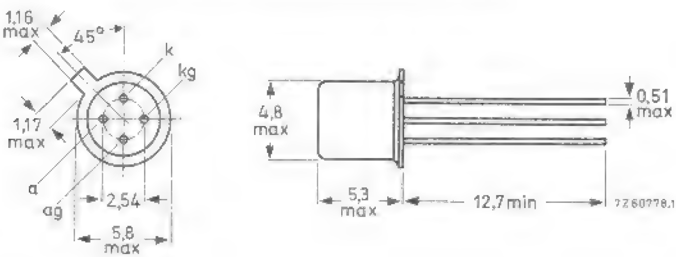
p-n-p transistor			
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50 V
n-p-n transistor			
Collector-base voltage (open emitter)	V_{CBO}	max.	50 V
Repetitive peak emitter current (peak value)	$-I_{ERM}$	max.	2,5 A
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	275 mW
Junction temperature	T_j	max.	150 ^{o}C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; $R_{KG\text{-}K}$ = 10 kΩ	V_{AK}	<	1,4 V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; $R_{KG\text{-}K}$ = 10 kΩ	I_H	<	1,0 mA

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Collector of the n-p-n transistor (ag = anode gate) connected to the case



Accessories: 56246 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

			p-n-p	n-p-n	
Collector-base voltage (open emitter)	V_{CBO}	max.	−50	50	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	–	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	−50	–	V
Emitter-base voltage (open collector)	V_{EBO}	max.	−50	5 1)	V

Currents

			p-n-p	n-p-n	
Emitter current (d.c.)	I_E	max.	175	−175	mA
Repetitive peak emitter current (peak value) t_p = 10 µs; δ = 0.01	I_{ERM}	max.	2,5	− 2,5	A
Collector current (d.c.)	I_C	max.	–	175 2)	mA
Collector current (peak value)	I_{CM}	max.	–	175	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

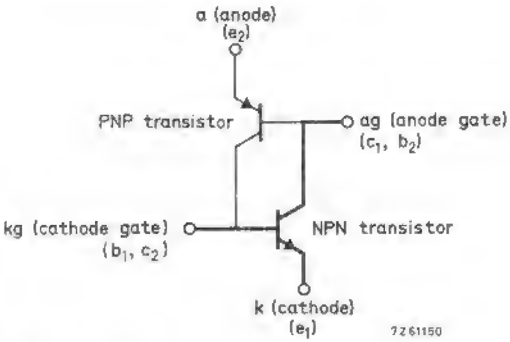
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,45	°C/mW

1) Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.

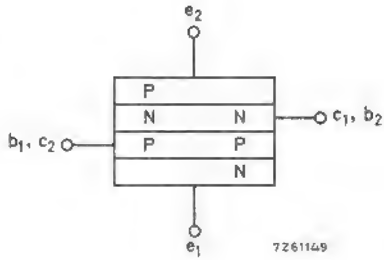
2) Provided the I_E rating will not be exceeded.

MEANING OF SYMBOLS , used in the schematic presentation of the S.C.S.

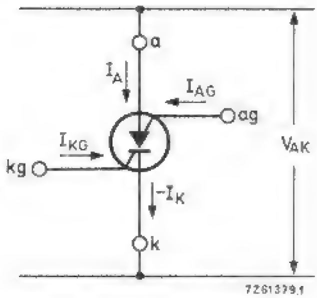
2 transistors equivalent circuit
n-p-n transistor + p-n-p transistor



p-n-p-n S.C.S. equivalent circuit



S.C.S. symbol



CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Individual N-P-N transistor

Collector cut-off current

$V_{CE} = 50$ V; $R_{BE} = 10$ kΩ	I_{CER}	<	0,5	μA
$V_{CE} = 50$ V; $R_{BE} = 10$ kΩ; $T_j = 150\ ^oC$	I_{CER}	<	50	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V; $T_j = 150\ ^oC$	I_{EBO}	<	50	μA

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Individual N-P-N transistor

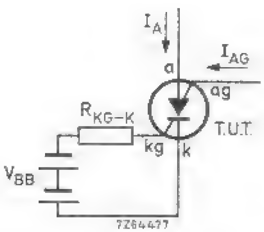
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 2$ V	h_{FE}	>	50	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25	pF

Individual P-N-P transistor

Collector cut-off current				
$I_B = 0$; $-V_{CE} = 50$ V; $T_j = 150\ ^oC$	$-I_{CEO}$	<	50	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 50$ V; $T_j = 150\ ^oC$	$-I_{EBO}$	<	50	μA
D.C. current gain				
$I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to 2,5		

Combined device

Forward on-state voltage at $R_{KG-K} = 10$ kΩ				
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4	V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2	V
→ Holding current at $R_{KG-K} = 10$ kΩ				
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0	mA



PROGRAMMABLE UNIJUNCTION TRANSISTOR

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper etc.

QUICK REFERENCE DATA

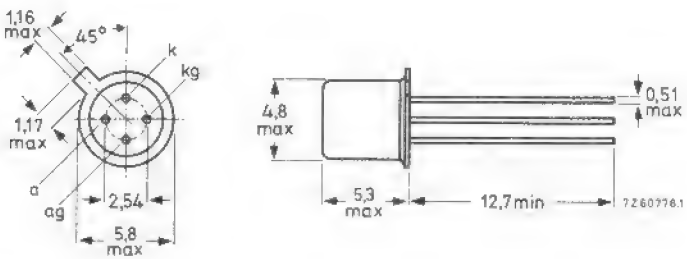
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Operating junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	25	μA

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Anode gate (ag) connected to case



Accessories: 56246 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{amb} = 25 °C	I_A	max.	175	mA
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Repetitive peak anode current t = 10 μs; δ = 0,01	I_{ARM}	max.	2,5	A
Non-repetitive peak anode current t = 10 μs; T_j = 150 °C	I_{ASM}	max.	3	A
Rate of rise of anode current up to I_A = 2,5 A	$\frac{dI_A}{dt}$	max.	20	A/μs
Storage temperature	T_{stg}	−65 to + 200		°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

EXPLANATION OF SYMBOLS

For application of the BRY39P as a programmable unijunction transistor only the anode gate is used. To simplify the symbols the term gate instead of anode gate will be used.

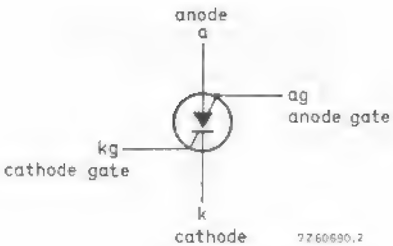


Fig. 2.

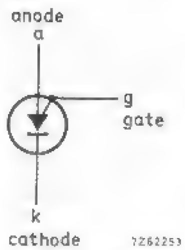


Fig. 3.

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

Peak point current			
$V_S = 10\ V$; $R_G = 10\ k\Omega$	I_P	<	5 μA
$V_S = 10\ V$; $R_G = 1\ M\Omega$	I_P	<	1 μA
Valley point current			
$V_S = 10\ V$; $R_G = 10\ k\Omega$	I_V	>	25 μA
$V_S = 10\ V$; $R_G = 1\ M\Omega$	I_V	<	50 μA

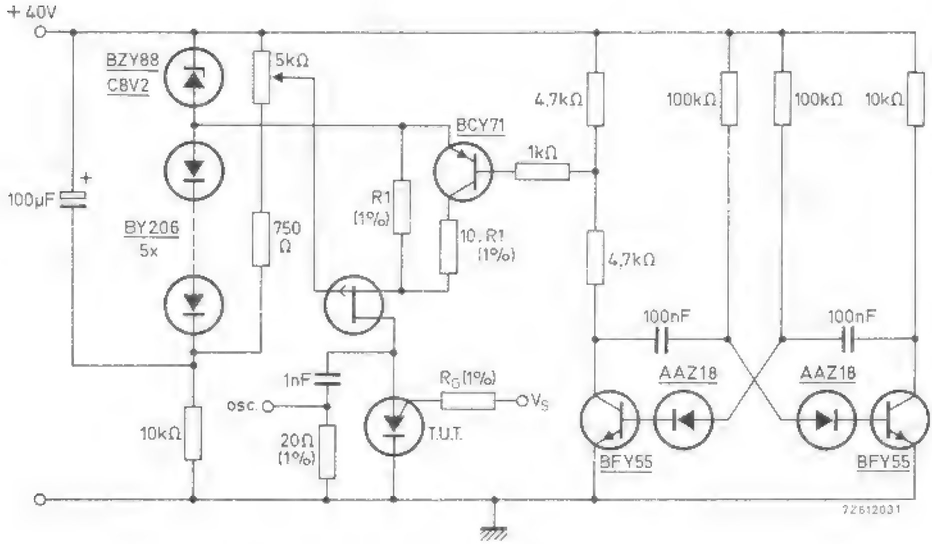


Fig. 4 Practical test circuit:
1. Remove BCY71 during measurement of I_P.
2. Value of R1 depends on the voltage range of voltmeter.

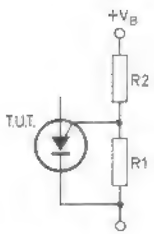


Fig. 5 **BRY39P** with "program" resistors R1 and R2.

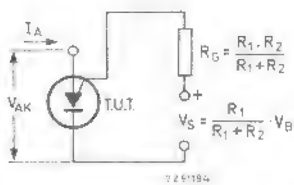


Fig. 6 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 7) $I_K = 0$; $V_{GA} = 70$ V	I_{GAO}	<	10 nA
Gate-cathode leakage current (see Fig. 8) $V_{AK} = 0$; $V_{GK} = 70$ V	I_{GKS}	<	100 nA
Offset voltage (see Figs 9 and 16) $V_{offset} = V_P - V_S$ ($I_A = 0$)			

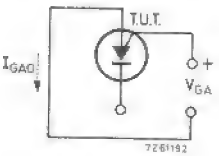


Fig. 7.

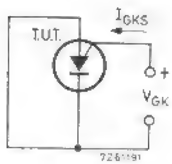


Fig. 8.

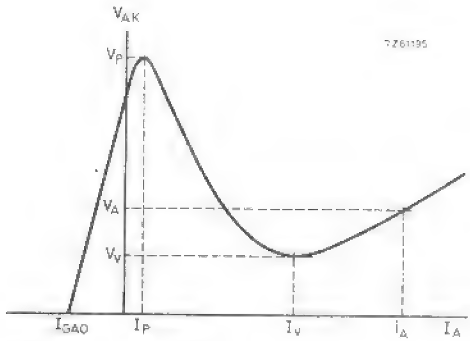


Fig. 9.

Anode voltage $I_A = 100$ mA	V_A	<	1,4 V
Peak output voltage (see Figs 10 and 11) $V_{AA} = 20$ V; C = 0,2 μF	V_{OM}	>	6 V
Rise time (see Figs 10 and 11) $V_{AA} = 20$ V; C = 10 nF	t_r	<	80 ns

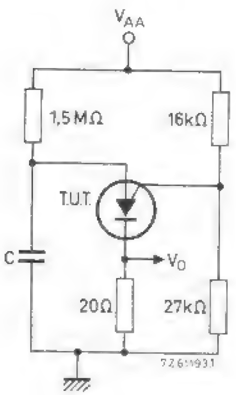


Fig. 10.

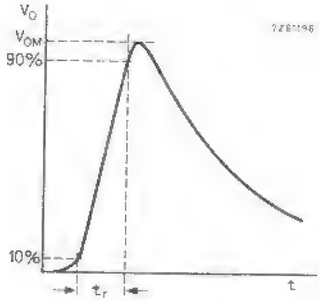


Fig. 11.

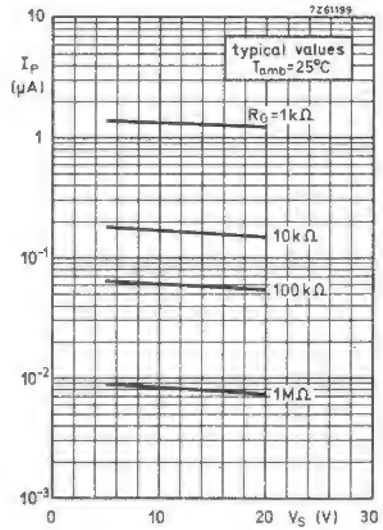


Fig. 12.

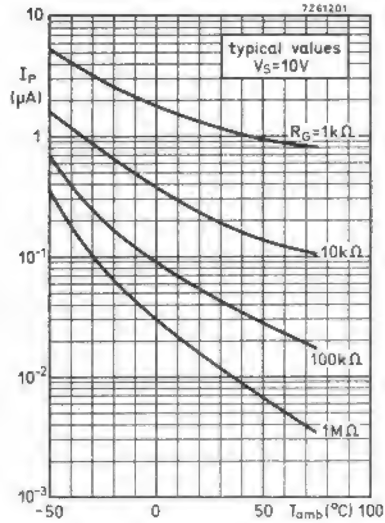


Fig. 13.

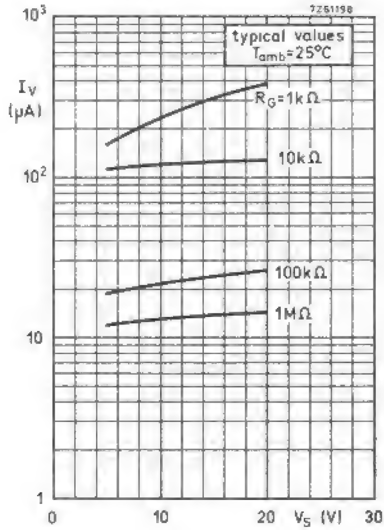


Fig. 14.

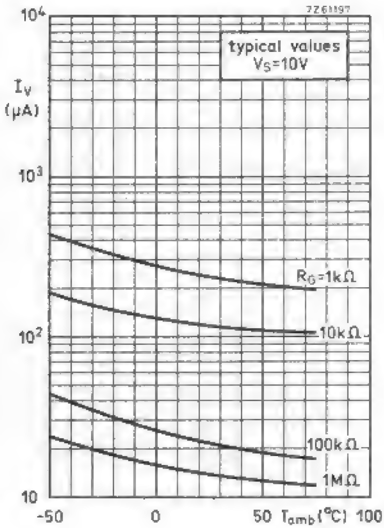


Fig. 15.

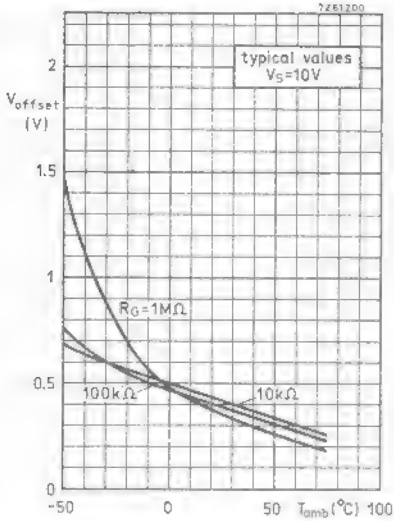

7Z61200
typical values
V_S=10V
V_{offset}
(V)
2
1.5
1
0.5
0
R_G=1MΩ
100kΩ
10kΩ
-50
0
50
T_{amb}(°C)
100

Fig. 16.

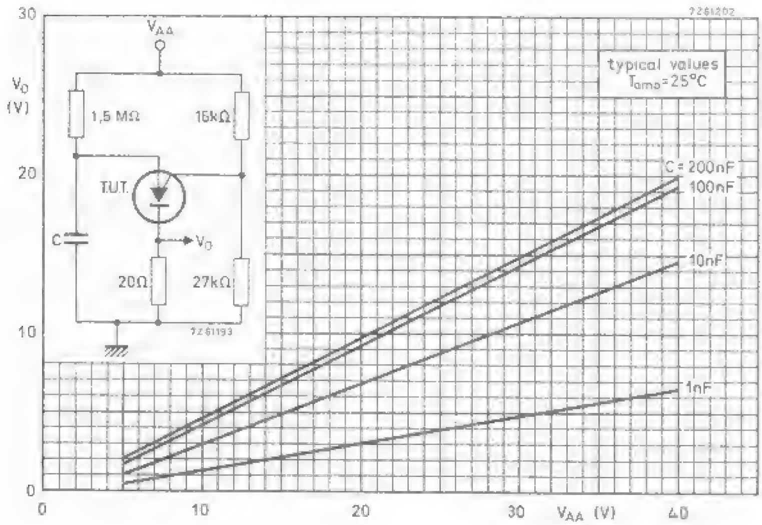

7Z61202
typical values
T_{amb}=25°C
V_O
(V)
30
20
10
0
V_{AA}
1,5 MΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
7Z61193
C = 200nF
100nF
10nF
1nF
0
10
20
30
V_{AA} (V)
40

Fig. 17.

SILICON CONTROLLED SWITCH

The BRY39 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for switching applications. It is an integrated p-n-p/n-p-n transistor pair, with all electrodes accessible.

QUICK REFERENCE DATA

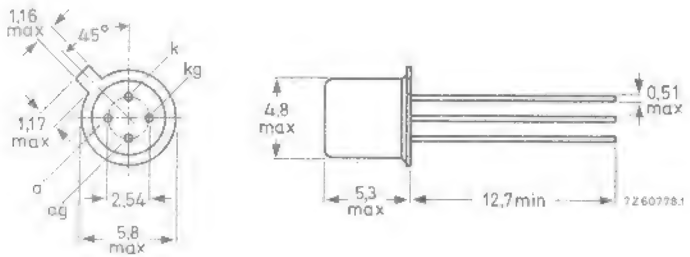
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Operating junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; $R_{KG\text{-}K}$ = 10 kΩ	V_{AK}	<	1,4	V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; $R_{KG\text{-}K}$ = 10 kΩ	I_H	<	1,0	mA
Turn-on time	t_{on}	<	0,25	µs
Turn-off time	t_q	<	5,0	µs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Collector of the n-p-n transistor (ag = anode gate) connected to the case



Accessories: 56246 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			p-n-p	n-p-n	
Collector-base voltage (open emitter)	V_{CBO}	max.	−70	70	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	−	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	−70	−	V
Emitter-base voltage (open collector)	V_{EBO}	max.	−70	5	V
Collector current (d.c.) *	I_C	max.	−	175	mA
Collector current (peak value) **	I_{CM}	max.	−	175	mA
Emitter current (d.c.)	I_E	max.	175	−175	mA
Repetitive peak emitter current	I_{ERM}	max.	2,5	−2,5	A

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Storage temperature	T_{stg}		−65 to + 200	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W

* Provided the I_E rating is not exceeded.

** During switching on, the device can withstand the discharge of a capacitor of maximum value of 500 pF. This capacitor is charged when the transistor is in cut-off condition, with a collector supply voltage of 160 V and a series resistance of 100 kΩ.

SYMBOLS AND EQUIVALENT CIRCUIT

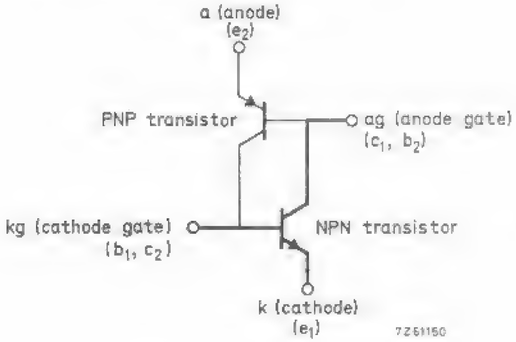


Fig. 2 Two transistor equivalent circuit.

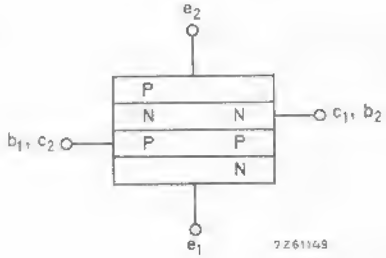


Fig. 3 P-N-P-N silicon controlled switch structure.

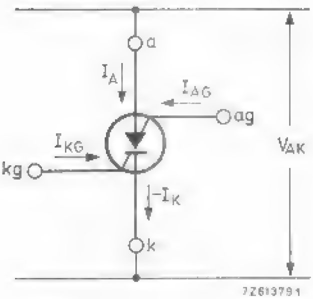


Fig. 4 Silicon controlled switch symbol.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Individual n-p-n transistor

Collector cut-off current			
$V_{CE} = 70$ V; $R_{BE} = 10$ kΩ	I_{CER}	<	100 nA
$V_{CE} = 70$ V; $R_{BE} = 10$ kΩ; $T_j = 150\ ^oC$	I_{CER}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 150\ ^oC$	I_{EBO}	<	10 μA
Saturation voltages			
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500 mV
	V_{BEsat}	<	900 mV
D.C. current gain			
$I_C = 10$ mA; $V_{CE} = 2$ V	h_{FE}	>	50
Transition frequency			
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300 MHz

Collector capacitance			
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5 pF
Emitter capacitance			
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25 pF
Individual p-n-p transistor			
Collector cut-off current			
$I_B = 0$; $-V_{CE} = 70$ V; $T_j = 150$ °C	$-I_{CEO}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 70$ V; $T_j = 150$ °C	$-I_{EBO}$	<	10 μA
D.C. current gain			
$I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to	2,5
Combined device			
Forward on-state voltage at $R_{KG\text{-}K} = 10$ kΩ			
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4 V
$I_A = 50$ mA; $I_{AG} = 0$; $T_j = -55$ °C	V_{AK}	<	1,9 V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2 V
Holding current at $R_{KG\text{-}K} = 10$ kΩ (see Fig. 5)			
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0 mA

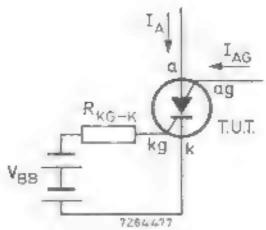


Fig. 5.

Switching times (see Figs 6 to 11)

Turn-on time when switched from

$-V_{KG\text{-}K} = 0{,}5$ V to $+V_{KG\text{-}K} = 4{,}5$ V

$R_{KG\text{-}K} = 1$ kΩ	t_{on}	<	0,25 μs
$R_{KG\text{-}K} = 10$ kΩ	t_{on}	<	1,50 μs

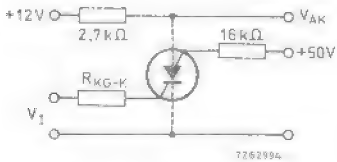


Fig. 6.

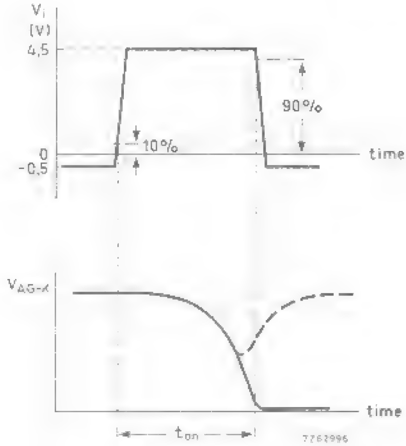


Fig. 7 Pulse duration increased until dashed curve disappears.

Turn-off time (see also Figs 8 and 9)

$R_{KG\text{-}K} = 1$ kΩ	t_q	<	5 μs
$R_{KG\text{-}K} = 10$ kΩ	t_q	<	8 μs
$R_{KG\text{-}K} = 10$ kΩ; $T_j = 125$ °C	t_q	<	15 μs

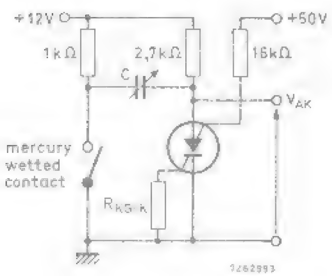


Fig. 8.

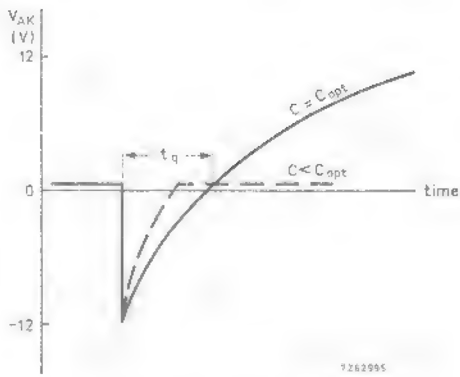


Fig. 9 Capacitance increased until at $C = C_{opt}$ dashed curve disappears.

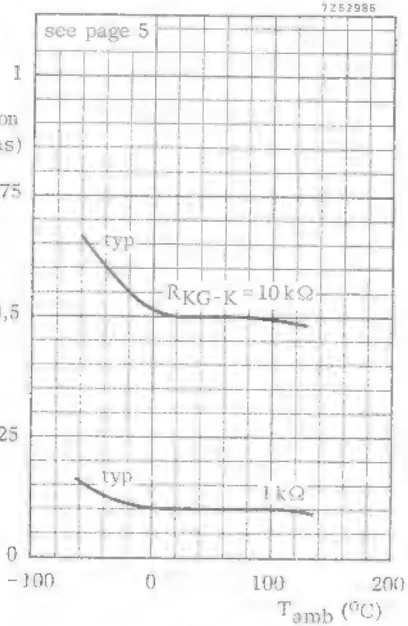


Fig. 10.

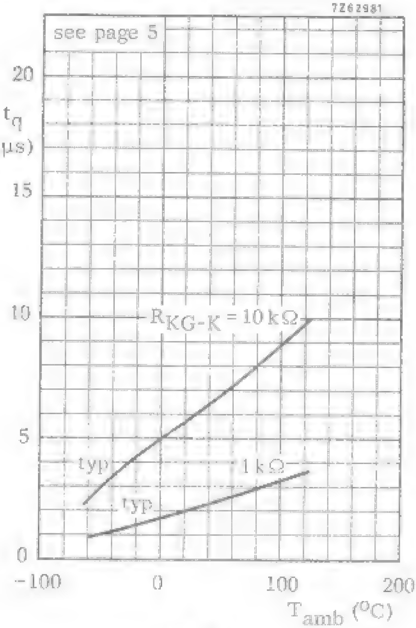


Fig. 11.

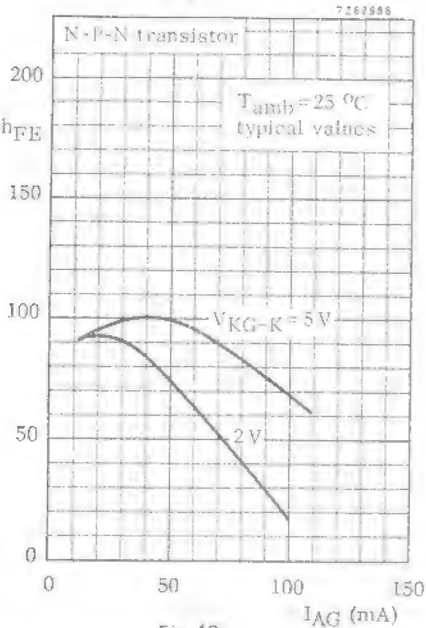


Fig. 12.

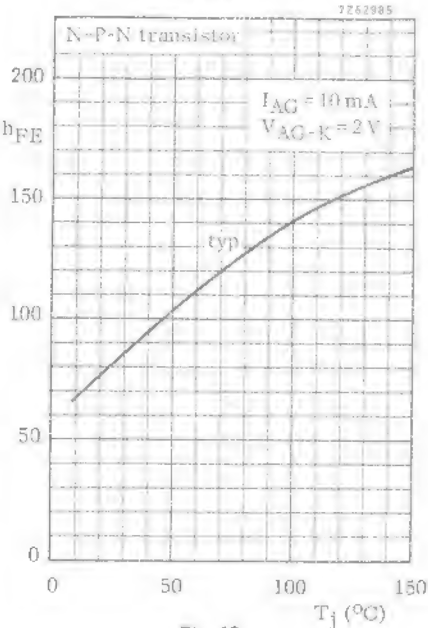


Fig. 13.

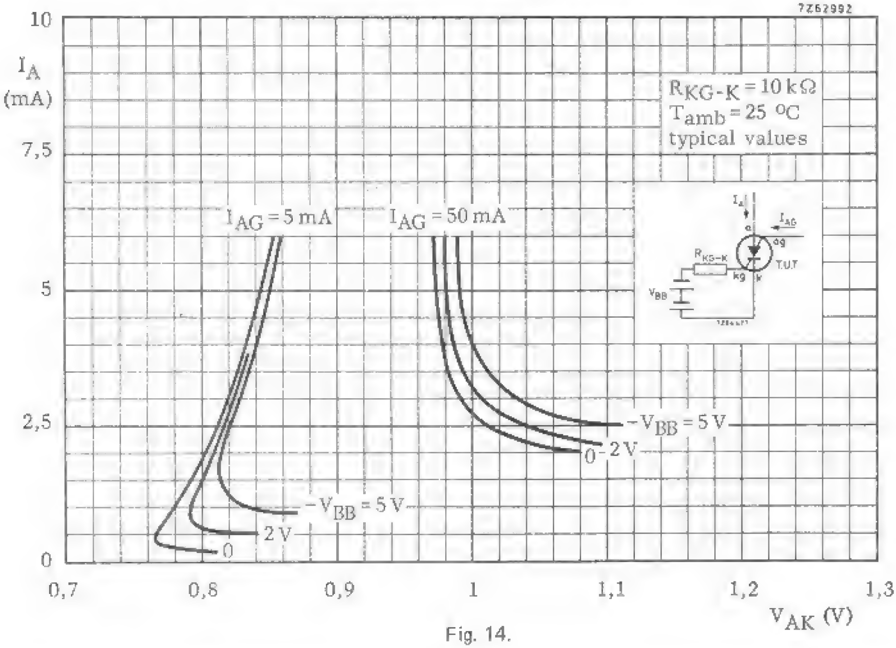

7Z62992
10
7,5
5
2,5
0
I_A
(mA)
$R_{KG-K} = 10\,k\Omega$
$T_{amb} = 25\ ^oC$
typical values
$I_{AG} = 5\,mA$
$I_{AG} = 50\,mA$
$-V_{BB} = 5\,V$
2 V
0
$-V_{BB} = 5\,V$
0
2 V
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)

Fig. 14.

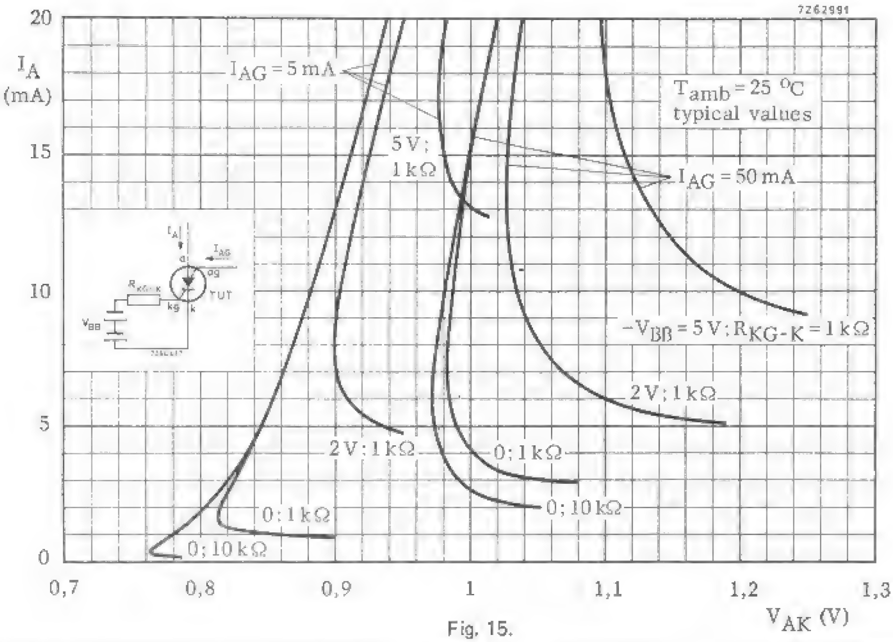

7Z62991
20
15
10
5
0
I_A
(mA)
$I_{AG} = 5\,mA$
$T_{amb} = 25\ ^oC$
typical values
5 V;
1 kΩ
$I_{AG} = 50\,mA$
$-V_{BB} = 5\,V; R_{KG-K} = 1\,k\Omega$
2 V; 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
0; 10 kΩ
0; 1 kΩ
0; 10 kΩ
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)

Fig. 15.

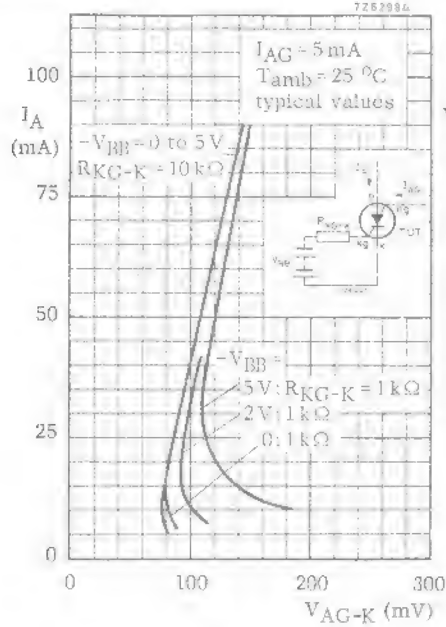


Fig. 16.

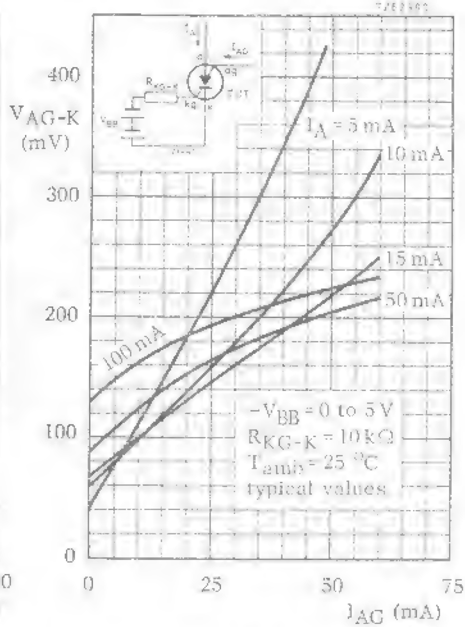


Fig. 17.

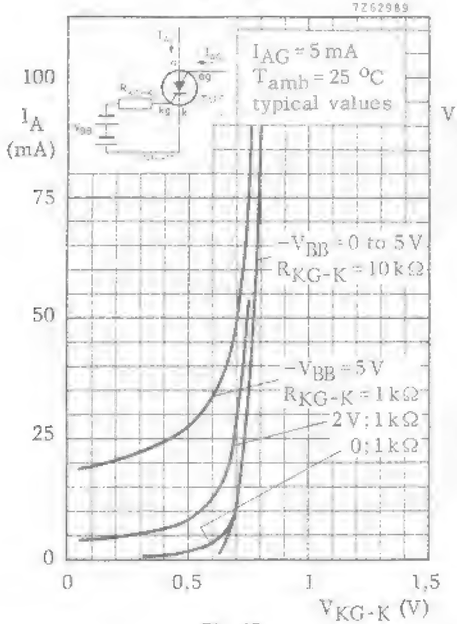


Fig. 18.

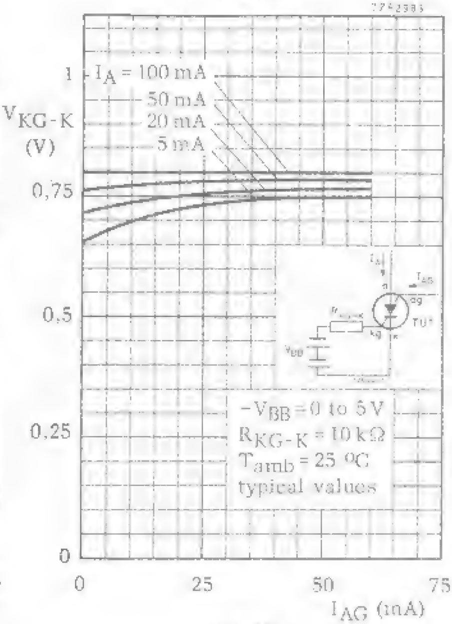


Fig. 19.

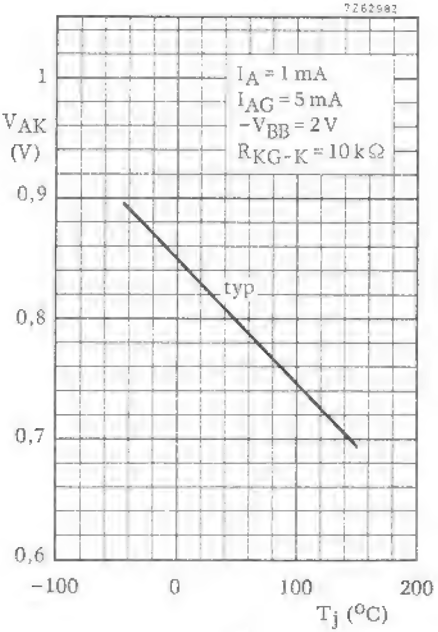


Fig. 20.

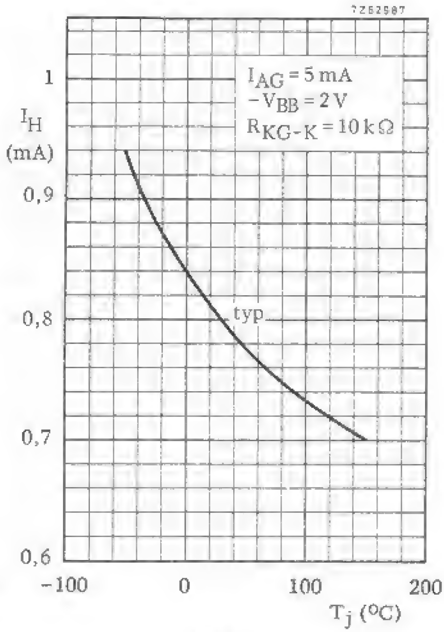


Fig. 21.

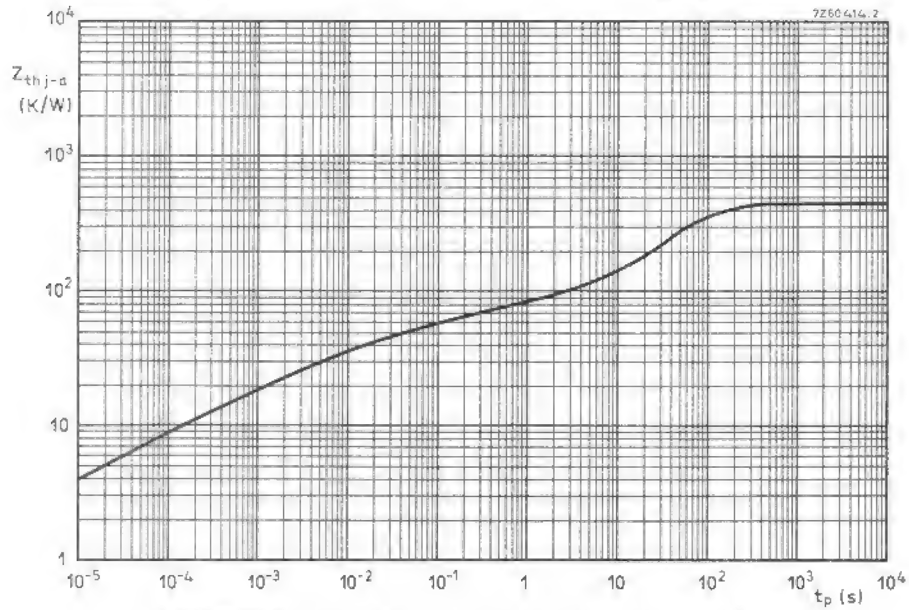


Fig. 22 Thermal impedance from junction to ambient versus pulse duration.

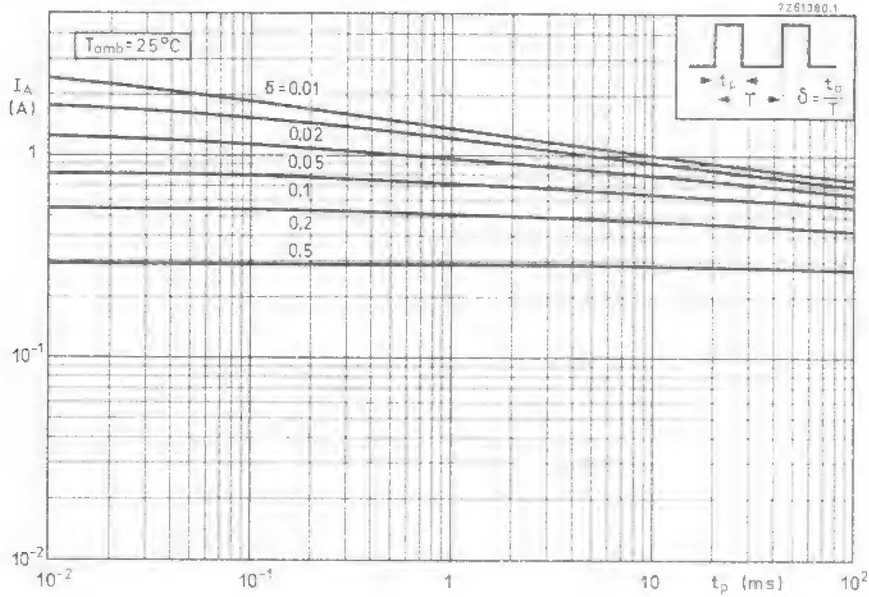

7Z61380.1
T_{amb} = 25 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 23.

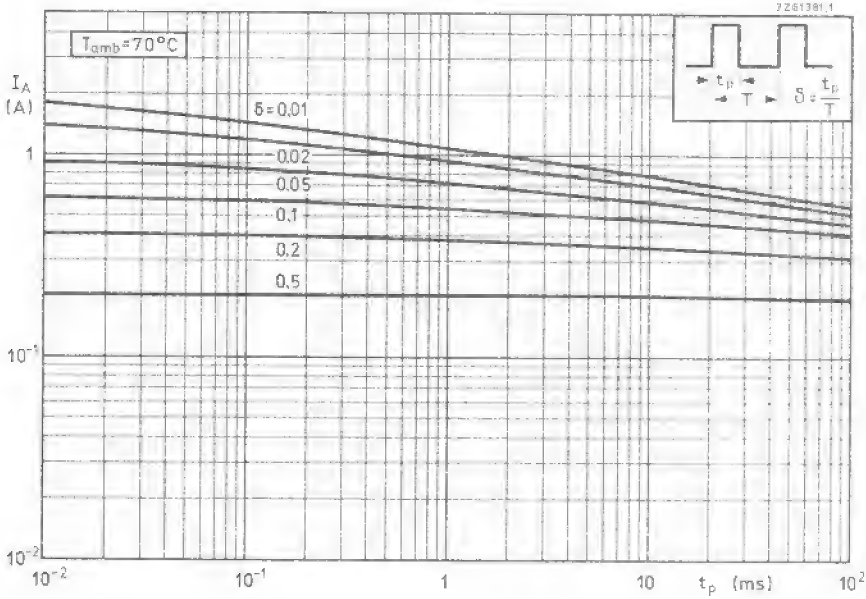

7Z61381.1
T_{amb} = 70 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 24.

THYRISTOR TETRODE

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in low-power switching applications such as relay and lamp drivers, sensing network for temperature and as a trigger device for thyristors and triacs.

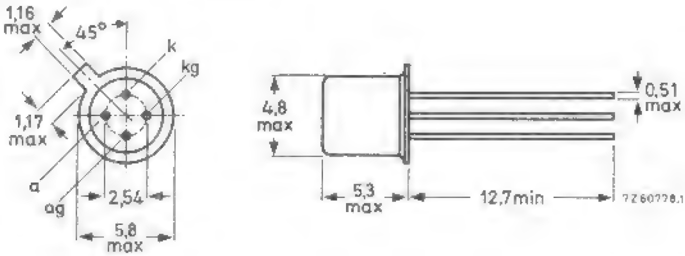
QUICK REFERENCE DATA

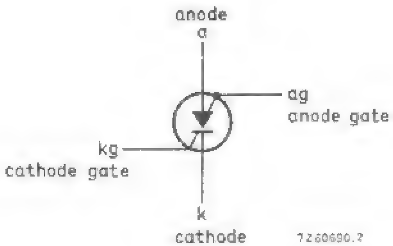
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70	V
Average on-state current	$I_{T(AV)}$	max.	250	mA
Non-repetitive peak on-state current	I_{TSM}	max.	3	A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–72; Anode gate connected to case.





Accessories supplied on request: 56246 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

Non-repetitive peak voltages	$V_{DSM} = V_{RSM}$	max.	70	V*
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70	V*
Continuous voltages	$V_D = V_R$	max.	70	V*
Average on-state current up to T_{case} = 85 °C	$I_{T(AV)}$	max.	250	mA
in free air up to T_{amb} = 25 °C	$I_{T(AV)}$	max.	175	mA
Repetitive peak on-state current $t = 10\ \mu s$; $\delta = 0.01$	I_{TRM}	max.	2,5	A
Non-repetitive peak on-state current $t = 10\ \mu s$; T_j = 150 °C prior to surge	I_{TSM}	max.	3	A
Rate of rise of on-state current after triggering to I_T = 2.5 A	$\frac{dI_T}{dt}$	max.	20	A/µs

Cathode gate to cathode

Peak reverse voltage	V_{RGKM}	max.	5	V
Peak forward current	I_{FGKM}	max.	100	mA

Anode gate to anode

Peak reverse voltage	V_{RGAM}	max.	70	V
Peak forward current	I_{FGAM}	max.	100	mA

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

*These ratings apply for zero or negative bias on the cathode gate with respect to the cathode, and when a resistor $R \leqslant 10\ k\Omega$ is connected between cathode gate and cathode.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 100$ mA; $T_j = 25$ °C	V_T	<	1.4	V*
Rate of rise of off-state voltage that will not trigger any device	$\frac{dV_D}{dt}$**			
Reverse current $V_R = 70$ V; $T_j = 25$ °C	I_R	typ.	1	nA
		<	100	nA
$T_j = 150$ °C	I_R	<	2	µA
Off-state current $V_D = 70$ V; $T_j = 25$ °C	I_D	typ.	1	nA
		<	100	nA
$T_j = 150$ °C	I_D	<	2	µA
Holding current $R_{GK} = 10$ kΩ; $R_{GA} = 220$ kΩ; $T_j = 25$ °C	I_H	<	250	µA

Cathode gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GKT}	>	0.5	V
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GKT}	>	1	µA

Anode gate to anode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	$-V_{GAT}$	>	1	V
Current that will trigger all devices $V_D = 6$ V; $R_{GK} = 10$ kΩ; $T_j = 25$ °C	$-I_{GAT}$	>	100	µA

*Measured under pulse conditions to avoid excessive dissipation.

**The dV_D/dt is unlimited when the anode gate lead is returned to the supply voltage through a current limiting resistor.

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from V_D = 15 V to I_T = 150 mA; I_{GK} = 5 μA; dI_{GK}/dt = 5 μA/μs; T_j = 25 °C	t_{gt}	<	300	ns
Circuit-commutated turn-off time when switched from I_T = 150 mA to V_R = 15 V; $-dI_T/dt$ = 3 A/μs; dV_D/dt = 70 V/μs; V_D = 15 V	t_q	<	3	μs

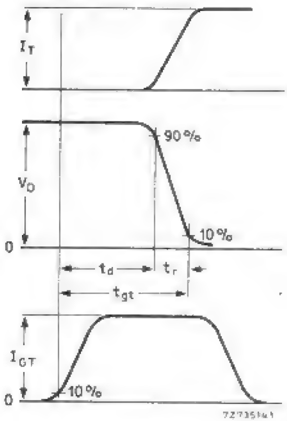


Fig.2 Gate-controlled turn-on time definition.

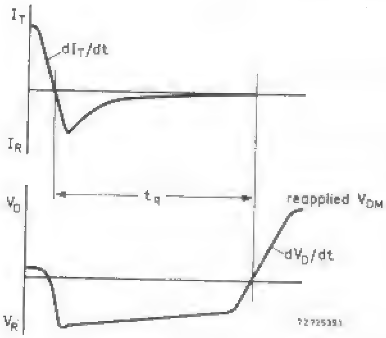


Fig.3 Circuit-commutated turn-off time definition.

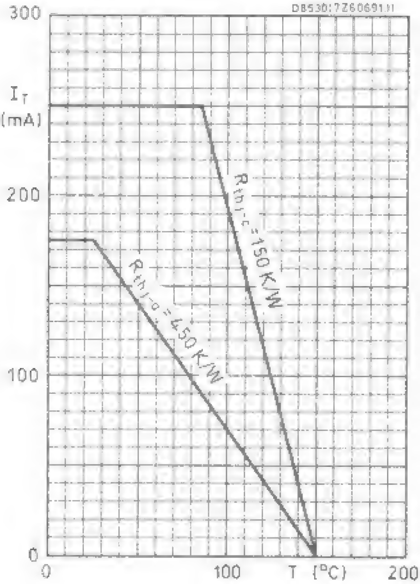


Fig.4

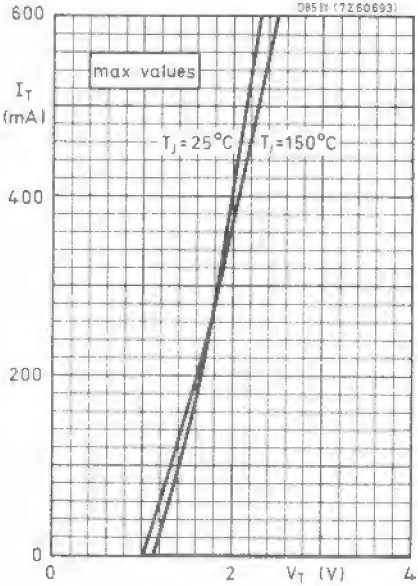


Fig.5

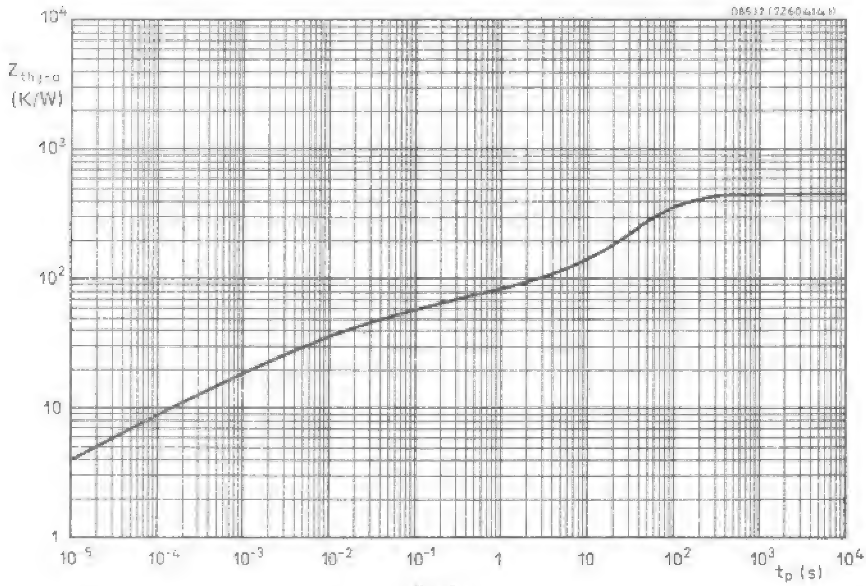


Fig.6

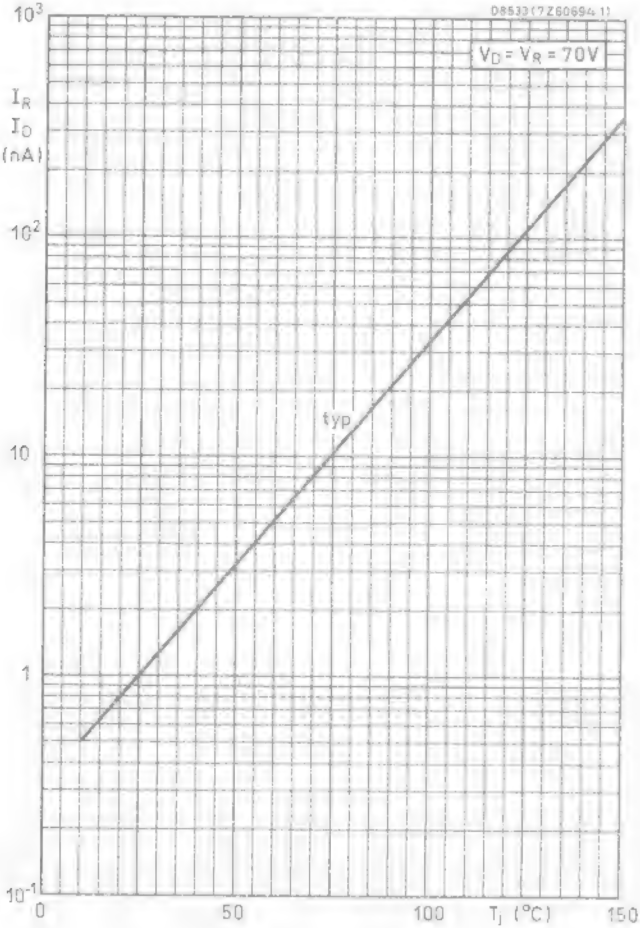

D8533 (7Z60694.1)
$V_D = V_R = 70V$
I_R
I_D
(nA)
10^3
10^2
10
1
10^{-1}
typ
0
50
100
150
T_j (°C)

Fig.7

APPLICATION INFORMATION

Sensing network

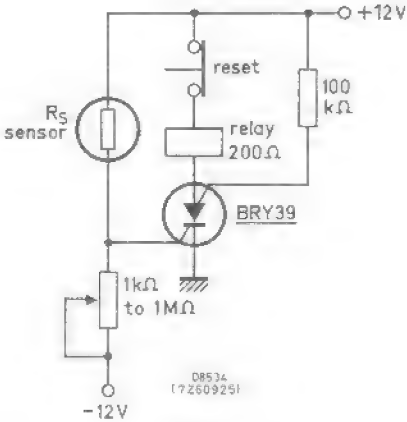


Fig.8

R_S must be chosen in accordance with the light, temperature, or radiation intensity to be sensed; its resistance should be of the same order as that of the potentiometer.
In the arrangement shown, a decline in resistance of R_S triggers the thyristor, closing the relay that activates the warning system. If the positions of R_S and the potentiometer are interchanged, an increase in the resistance of R_S triggers the thyristor.

PROGRAMMABLE UNIJUNCTION TRANSISTOR

Silicon planar p-n-p-n trigger device in a plastic TO-92 variant, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper etc.

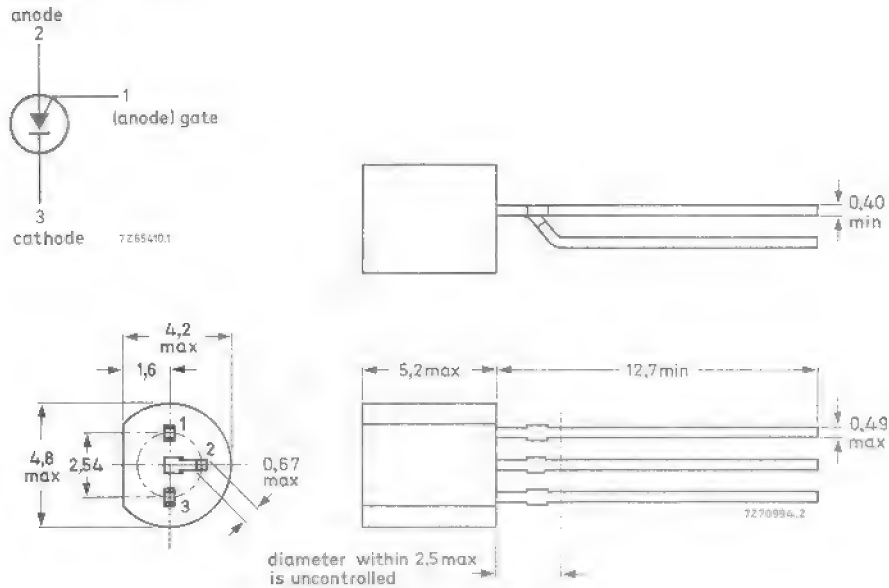
QUICK REFERENCE DATA

Gate-anode voltage	V_{GA}	max.	70	V
Anode current (average)	$I_{A(AV)}$	max.	175	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

→ Gate-anode voltage	V_{GA}	max.	70	V
Anode current (average)	$I_{A(AV)}$	max.	175	mA
Repetitive peak anode current t_p = 10 μs; δ = 0,01	I_{ARM}	max.	2,5	A
Non-repetitive peak anode current t_p = 10 μs	I_{ASM}	max.	3,0	A
Rate of rise of anode current up to I_A = 2,5 A	$\frac{dI_A}{dt}$	max.	20	A/μs
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	250	K/W

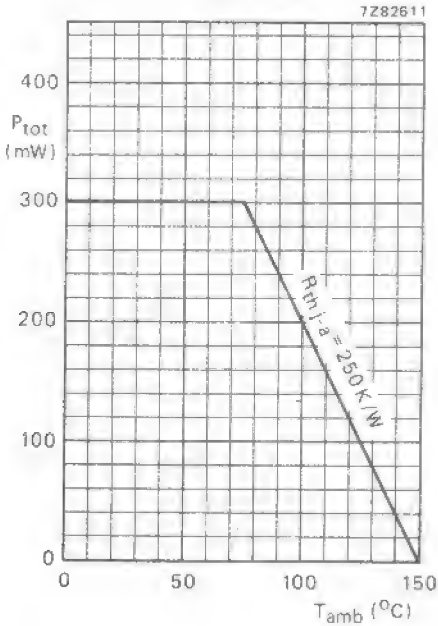


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

$T_{amb} = 25\ ^{o}C$

Peak point current (see Fig. 10)			
$V_S = 10$ V; $R_G = 10$ kΩ	I_P	<	5 μA
$V_S = 10$ V; $R_G = 100$ kΩ	I_P	<	2 μA
Valley point current (see Fig. 10)			
$V_S = 10$ V; $R_G = 10$ kΩ	I_V	>	50 μA
$V_S = 10$ V; $R_G = 100$ kΩ	I_V	>	5 μA

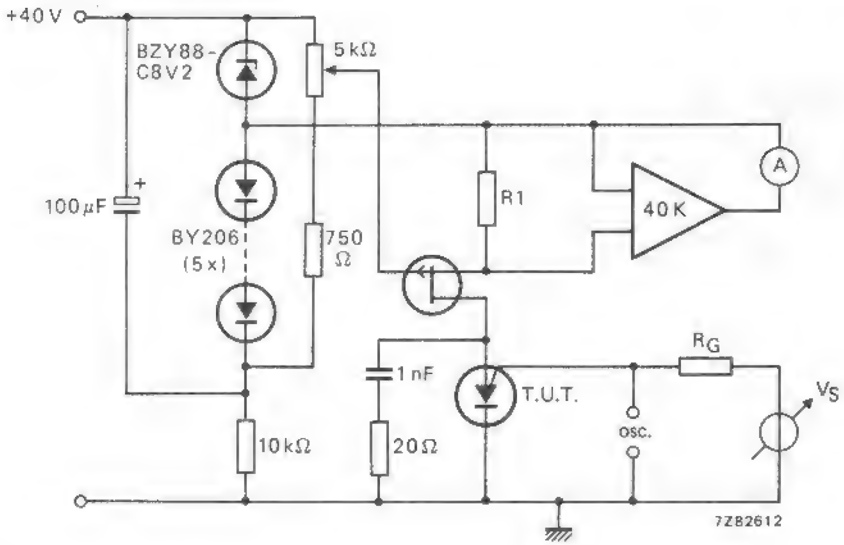


Fig. 3 Measuring circuit for I_P and I_V by means of value of R1. $R1 = \frac{1}{I_A}$ (that is maximum voltage drop over R1 is 1 V). Internal resistance of oscilloscope is 10 MΩ.

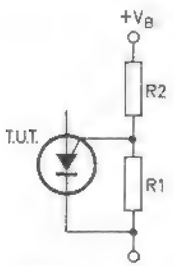


Fig. 4 **BRY56** with "program" resistors R1 and R2.

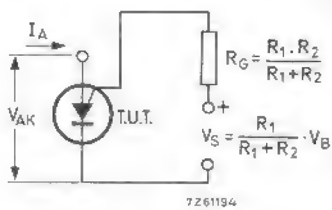


Fig. 5 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 6)
$I_K = 0$; $V_{GA} = 70$ V — I_{GAO} < 10 nA

Gate-cathode leakage current (see Fig. 7)
$V_{AK} = 0$; $V_{GK} = 70$ V — I_{GKS} < 100 nA

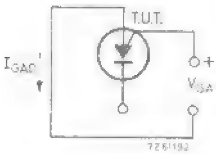


Fig. 6.

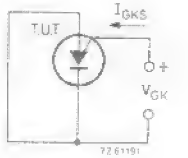


Fig. 7.

Anode-cathode voltage
$I_A = 100$ mA — V_{AK} < 1,4 V

Peak output voltage (see Figs 8 and 9)
$V_{AA} = 20$ V; C = 10 nF — V_{OM} > 6 V

Offset voltage (see Fig. 10) $V_{offset} = V_P - V_S$ ($I_A = 0$)

Rise time (see Fig. 9)
$V_{AA} = 20$ V; C = 10 nF — t_r < 80 ns

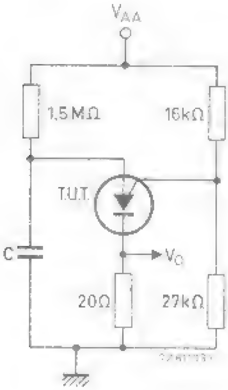


Fig. 8.

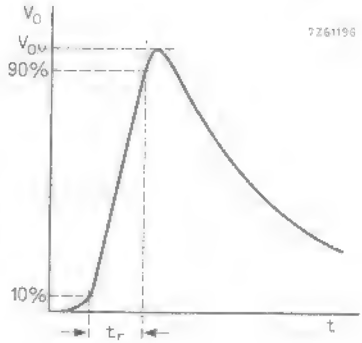


Fig. 9.

7Z82610

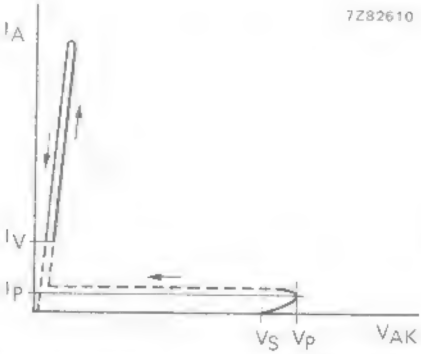


Fig. 10.

N-P-N DARLINGTON TRANSISTORS

Silicon planar transistors in plastic TO-92 envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

P-N-P complements are the BSR60, BSR61 and BSR62.

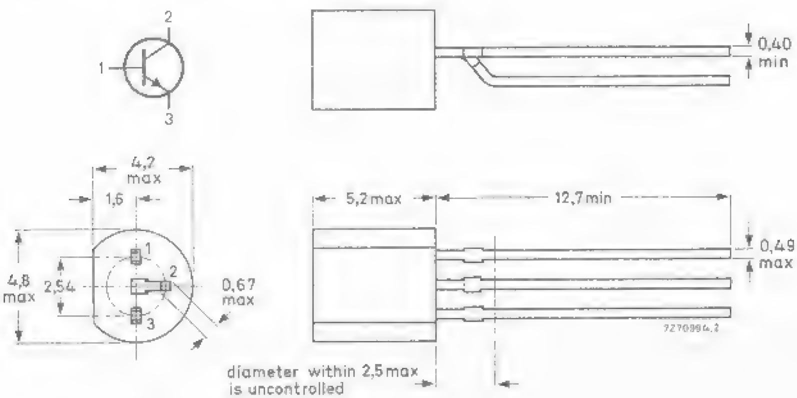
QUICK REFERENCE DATA

			BSR50	BSR51	BSR52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	V
Collector-emitter voltage (see Fig. 5)	V_{CER}	max.	45	60	80	V
Collector current (average)	$I_{C(AV)}$	max.		1,0		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
Junction temperature	T_j	max.		150		°C
Collector-emitter saturation voltage I_C = 0,5 A; I_B = 0,5 mA	V_{CEsat}	<		1,3		V
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>		1000		
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>		2000		
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA	t_{off}	<		1,5		μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant, for circuit diagram see Fig. 2.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSR50	BSR51	BSR52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	V
Collector-emitter voltage (see Fig. 5)	V_{CER}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (average)	$I_{C(AV)}$	max.		1,0		A
Collector current (peak value)	I_{CM}	max.		2,0		A
Base current (d.c.)	I_B	max.		0,1		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{amb} = 25 °C *	P_{tot}	max.		1,0		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	K/W

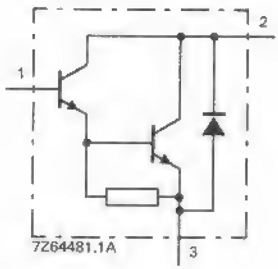


Fig. 2 Circuit diagram.

* Transistor mounted on printed-circuit board, maximum lead length 3 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

** Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$

Collector cut-off voltage				
$I_E = 0$; $V_{CB} = 45$ V	BSR50	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 60$ V	BSR51	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 80$ V	BSR52	I_{CBO}	<	50 nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V		I_{EBO}	<	50 nA
Saturation voltages				
$I_C = 0,5$ A; $I_B = 0,5$ mA		V_{CEsat}	<	1,3 V
		V_{BEsat}	<	1,9 V
$I_C = 1,0$ A; $I_B = 1,0$ mA	BSR51	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1,0$ A; $I_B = 4,0$ mA	BSR50; BSR52	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
D.C. current gain				
$I_C = 150$ mA; $V_{CE} = 10$ V		h_{FE}	>	1000
$I_C = 500$ mA; $V_{CE} = 10$ V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$I_C = 500$ mA; $V_{CE} = 5$ V		h_{fe}	typ.	10

Switching times see page 4.

Switching times (see Figs 3 and 4)

I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	<	1,5 μs

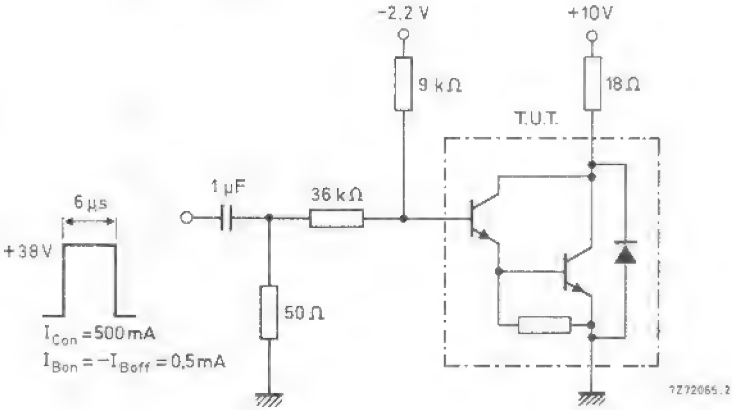


Fig. 3 Test circuit for 500 mA switching.

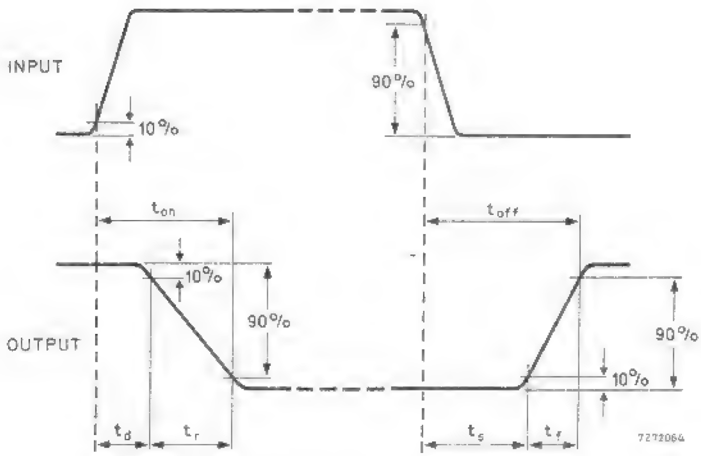


Fig. 4 Switching waveforms.

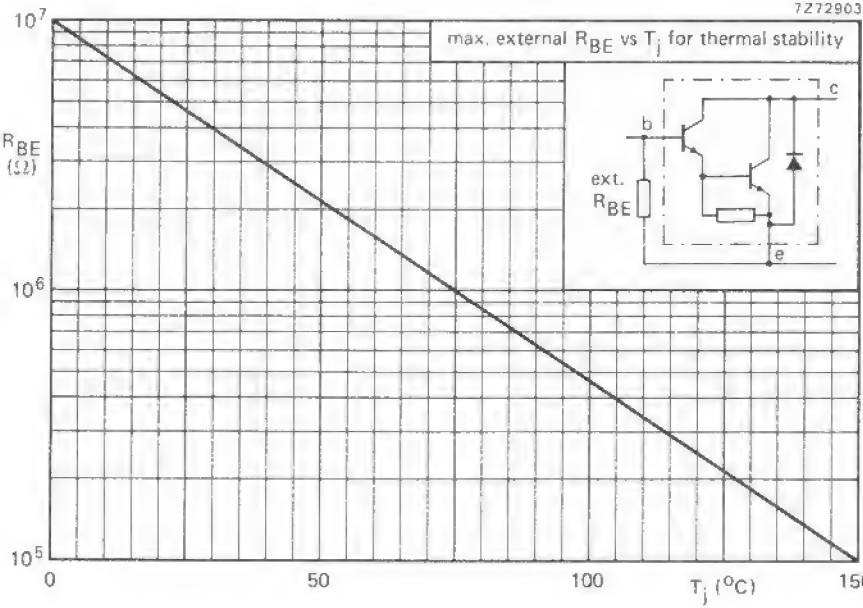


Fig. 5.

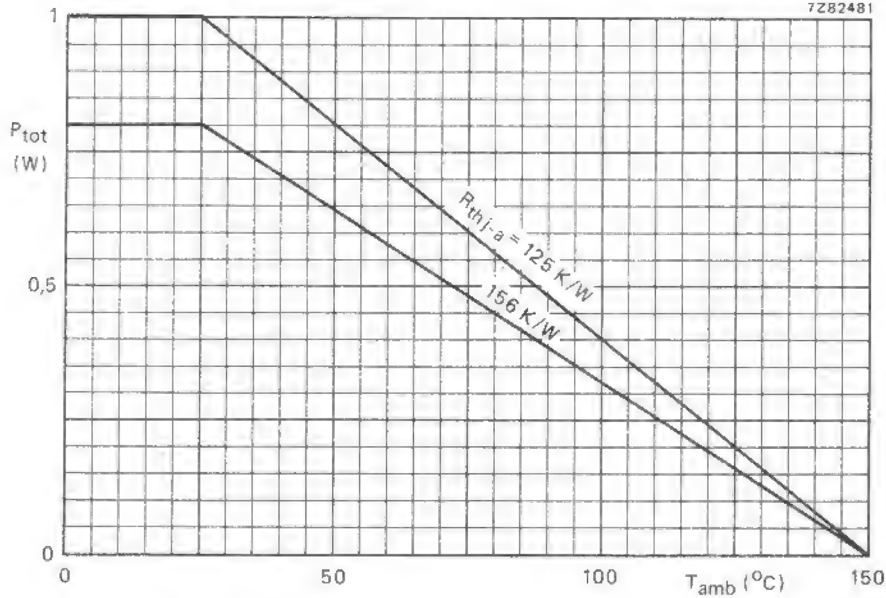


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

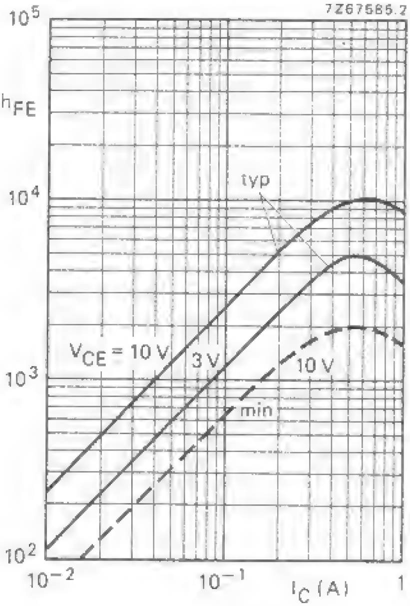


Fig. 7 T_j = 25 °C.

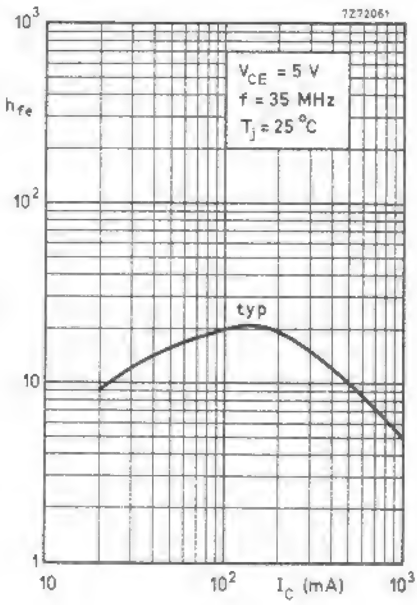


Fig. 8.

P-N-P DARLINGTON TRANSISTORS

Silicon planar transistors in plastic TO-92 envelopes, intended for industrial applications e.g. print hammer, solenoid, relay and lamp driving.

N-P-N complements are the BSR50, BSR51 and BSR52.

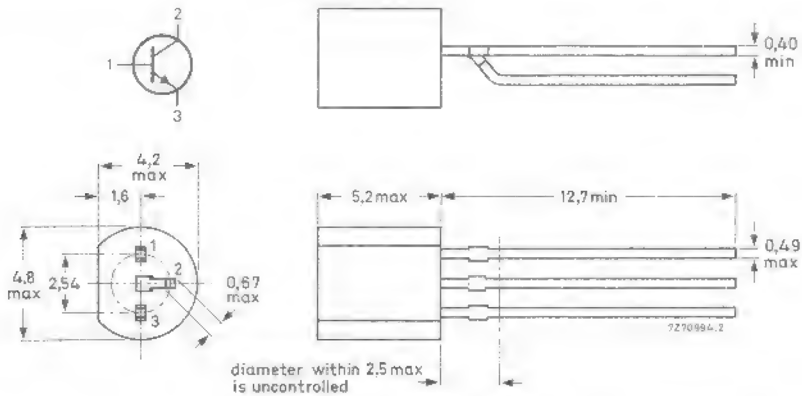
QUICK REFERENCE DATA

			BSR60	BSR61	BSR62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage (see Fig. 6)	$-V_{CER}$	max.	45	60	80	V
Collector current (average)	$-I_{C(AV)}$	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	150	150	150	°C
Collector-emitter saturation voltage $-I_C$ = 0,5 A; $-I_B$ = 0,5 mA	$-V_{CEsat}$	<	1,3	1,3	1,4	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	>		1000		
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>		2000		
Turn-off time when switched from $-I_{Con}$ = 500 mA; $-I_{Bon}$ = 0,5 mA to cut-off with $+I_{Boff}$ = 0,5 mA	t_{off}	<		1,5		μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant, for circuit diagram see Fig. 2.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSR60	BSR61	BSR62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage (see Fig. 6)	$-V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (average)	$-I_{C(AV)}$	max.		1,0		A
Collector current (peak value)	$-I_{CM}$	max.		2,0		A
Base current (d.c.)	$-I_B$	max.		0,1		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{amb} = 25 °C *	P_{tot}	max.		1,0		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	K/W

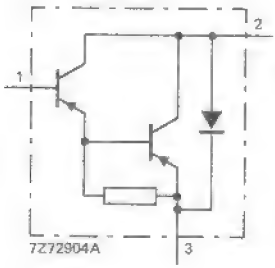


Fig. 2 Circuit diagram.

* Transistor mounted on printed-circuit board, maximum lead length 3 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

** Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$

Collector cut-off current				
$I_E = 0; -V_{CB} = 45$ V	BSR60	$-I_{CBO}$	<	50 nA
$I_E = 0; -V_{CB} = 60$ V	BSR61	$-I_{CBO}$	<	50 nA
$I_E = 0; -V_{CB} = 80$ V	BSR62	$-I_{CBO}$	<	50 nA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 4$ V		$-I_{EBO}$	<	50 nA
Saturation voltages				
$-I_C = 0{,}5$ A; $-I_B = 0{,}5$ mA	BSR60; BSR61	$-V_{CEsat}$	<	1,3 V
		$-V_{BEsat}$	<	1,9 V
$-I_C = 0{,}5$ A; $-I_B = 0{,}5$ mA	BSR62	$-V_{CEsat}$	<	1,4 V
		$-V_{BEsat}$	<	2,0 V
$-I_C = 1{,}0$ A; $-I_B = 1{,}0$ mA	BSR61	$-V_{CEsat}$	<	1,6 V
		$-V_{BEsat}$	<	2,2 V
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA	BSR60	$-V_{CEsat}$	<	1,6 V
		$-V_{BEsat}$	<	2,2 V
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA	BSR62	$-V_{CEsat}$	<	1,8 V
		$-V_{BEsat}$	<	2,4 V
D.C. current gain				
$-I_C = 150$ mA; $-V_{CE} = 10$ V		h_{FE}	>	1000
$-I_C = 500$ mA; $-V_{CE} = 10$ V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$-I_C = 500$ mA; $-V_{CE} = 5$ V		h_{fe}	typ.	10

Switching times see page 4.

Switching times (see Figs 3 and 4)

$-I_{Con} = 500$ mA; $-I_{Bon} = +I_{Boff} = 0{,}5$ mA

Turn-on time	t_{on}	<	1,0 μs
Turn-off time	t_{off}	<	1,5 μs

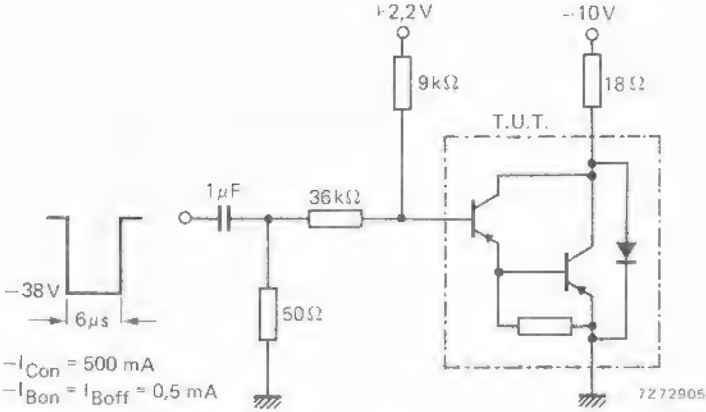


Fig. 3 Test circuit for 500 mA switching.

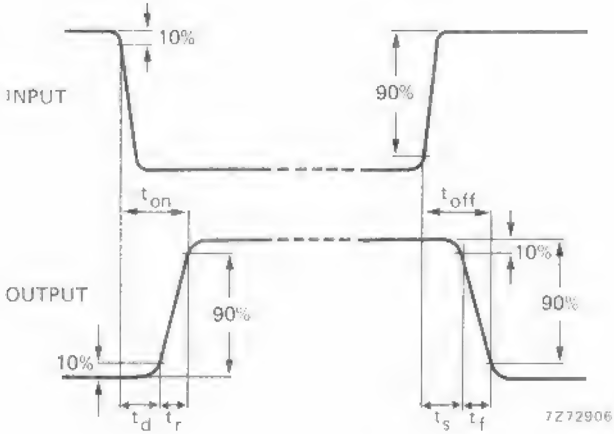


Fig. 4 Switching waveforms.

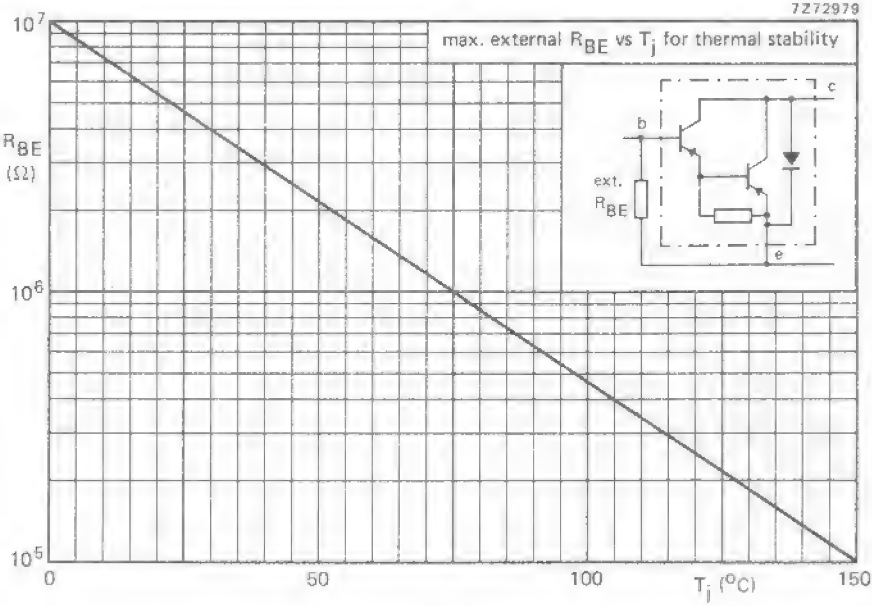


Fig. 5.

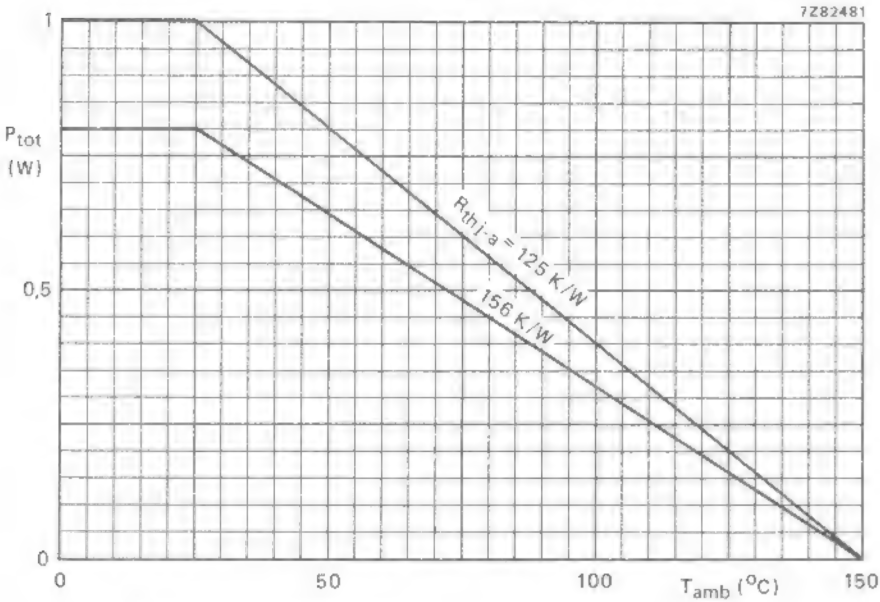


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

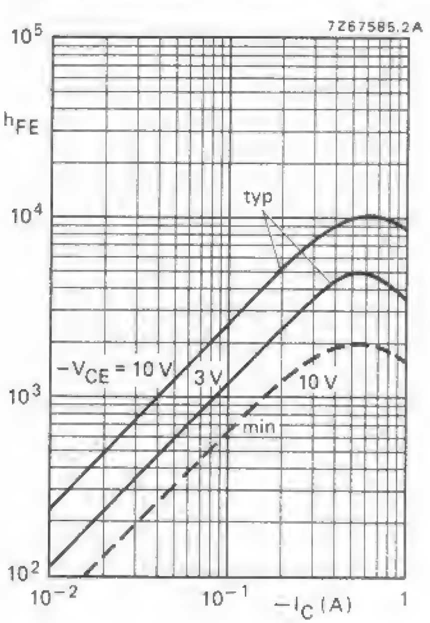


Fig. 7 T_j = 25 °C.

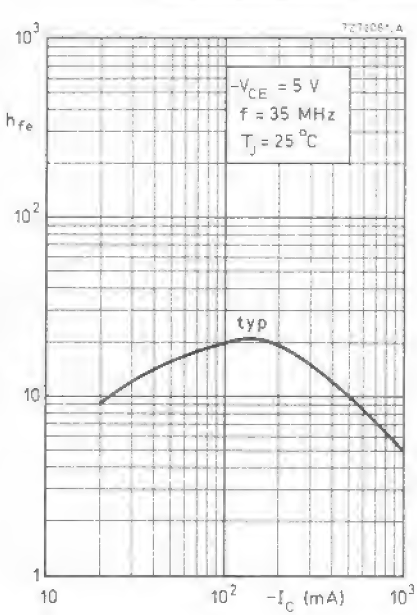


Fig. 8.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant. It is primarily intended for general purpose switching and as driver for numerical indicator tubes.

QUICK REFERENCE DATA

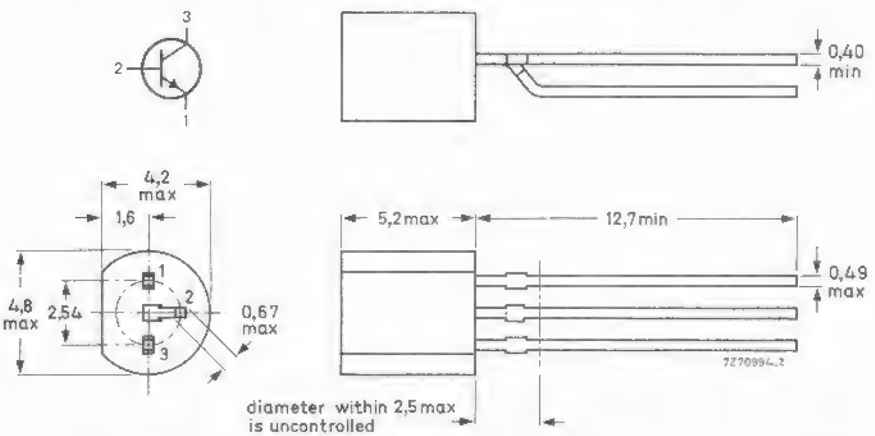
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 4 mA; V_{CE} = 1 V	h_{FE}	> typ.	20 80	
Transition frequency at f = 35 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz
Turn-off time I_{Con} = 15 mA; I_{Bon} = 1 mA; $-I_{Boff}$ = 1 mA	t_{off}	<	1	µs

Note
The BSS38 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	120 V*
Collector-emitter voltage (open base)	V_{CEO}	max.	100 V*
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c. or averaged over any 20 ms period)	$I_{C(AV)}$	max.	100 mA
Collector current (peak value)	I_{CM}	max.	250 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25 °C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

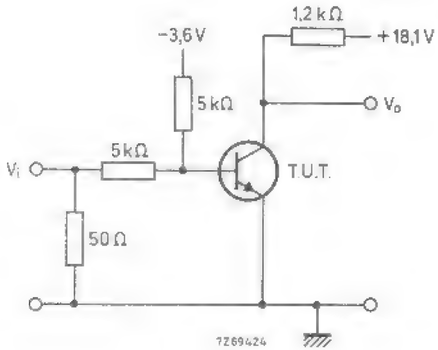
Collector cut-off current			
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	200 nA
$I_E = 0$; $V_{CB} = 90$ V; $T_j = 150$ °C	I_{CBO}	<	50 μA
$V_{BE} = 0$; $V_{CE} = 80$ V; $T_j = 85$ °C	I_{CES}	<	20 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	200 nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50 μA
Saturation voltages			
I_C = 4 mA; I_B = 0,4 mA	V_{CEsat}	<	0,7 V
	V_{BEsat}	<	1,2 V
I_C = 50 mA; I_B = 15 mA	V_{CEsat}	<	3,0 V
D.C. current gain			
I_C = 4 mA; V_{CE} = 1 V	h_{FE}	>	20
		typ.	80
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	typ.	80

* The BSS38 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

CHARACTERISTICS (continued)

Transition frequency at f = 35 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	>	60 MHz
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; V_{CB} = 10 V	C_c	<	4,5 pF
Emitter capacitance at f = 1 MHz $I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	<	17 pF
Switching time Turn-off time when switched from I_{Con} = 15 mA; I_{Bon} = 1 mA to cut-off with $-I_{Boff}$ = 1 mA	t_{off}	<	1 μs

Test circuit for measuring turn-off time:



Pulse generator:

Input voltage	V_i	=	+ 10 V
Pulse duration	t_p	=	1 μs
Duty factor	δ	=	0,01
Source impedance	Z_S	=	50 Ω

N-P-N DARLINGTON TRANSISTORS

Silicon planar transistors in TO-39 metal envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

P-N-P complements are the BSS60, BSS61 and BSS62.

QUICK REFERENCE DATA

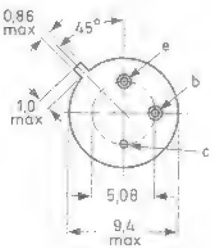
				BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)		V_{CBO}	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)		V_{CER}	max.	45	60	80	V
Collector current (d.c.)		I_C	max.		1,0		A
Total power dissipation							
up to T_{amb} = 25 °C		P_{tot}	max.		0,8		W
up to T_{case} = 25 °C		P_{tot}	max.		5,0		W
Collector-emitter saturation voltage							
I_C = 1,0 A; I_B = 1,0 mA	BSS51	V_{CEsat}	<		1,6		V
I_C = 1,0 A; I_B = 4,0 mA	BSS50; BSS52	V_{CEsat}	<		1,6		V
D.C. current gain							
I_C = 500 mA; V_{CE} = 10 V		h_{FE}	>		2000		
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA		t_{off}	typ.		1,5		μs

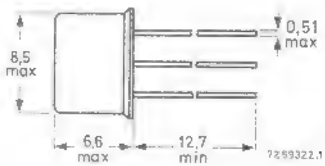
MECHANICAL DATA

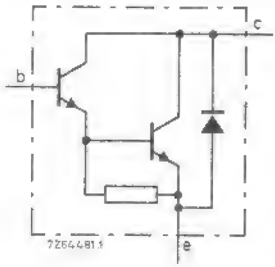
Dimensions in mm

Fig. 1 TO-39.

Collector connected to case







Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-073, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)	V_{CER}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5,0	5,0	5,0	V

Collector current (d.c.)	I_C	max.	1,0	A
Collector current (peak value)	I_{CM}	max.	2,0	A
Base current (d.c.)	I_B	max.	0,1	A
Total power dissipation				
up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Storage temperature	T_{stg}		−65 to + 200	°C
Junction temperature *	T_j	max.	200	°C

THERMAL RESISTANCE *

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	BSS50	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 60$ V	BSS51	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 80$ V	BSS52	I_{CBO}	<	50 nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4{,}0$ V		I_{EBO}	<	50 nA
Base-emitter voltage				
$I_C = 150$ mA; $V_{CE} = 10$ V		V_{BE}		1,3 to 1,65 V
$I_C = 500$ mA; $V_{CE} = 10$ V		V_{BE}		1,4 to 1,75 V
Saturation voltages				
$I_C = 500$ mA; $I_B = 0{,}5$ mA		V_{CEsat}	<	1,3 V
		V_{BEsat}	<	1,9 V
$I_C = 500$ mA; $I_B = 0{,}5$ mA; $T_j = 200$ °C		V_{CEsat}	<	1,3 V
$I_C = 1{,}0$ A; $I_B = 1{,}0$ mA	BSS51	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1{,}0$ A; $I_B = 1{,}0$ mA; $T_j = 200$ °C	BSS51	V_{CEsat}	<	2,3 V
$I_C = 1{,}0$ A; $I_B = 4{,}0$ mA	BSS50; BSS52	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1{,}0$ A; $I_B = 4{,}0$ mA; $T_j = 200$ °C	BSS50; BSS52	V_{CEsat}	<	1,6 V
D.C. current gain				
$I_C = 150$ mA; $V_{CE} = 10$ V		h_{FE}	>	1000
$I_C = 500$ mA; $V_{CE} = 10$ V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$I_C = 500$ mA; $V_{CE} = 5$ V		h_{fe}	typ.	10

Switching times (see Figs 2 and 3)

I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA			
Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs
I_{Con} = 1,0 A; I_{Bon} = $-I_{Boff}$ = 1,0 mA			
Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

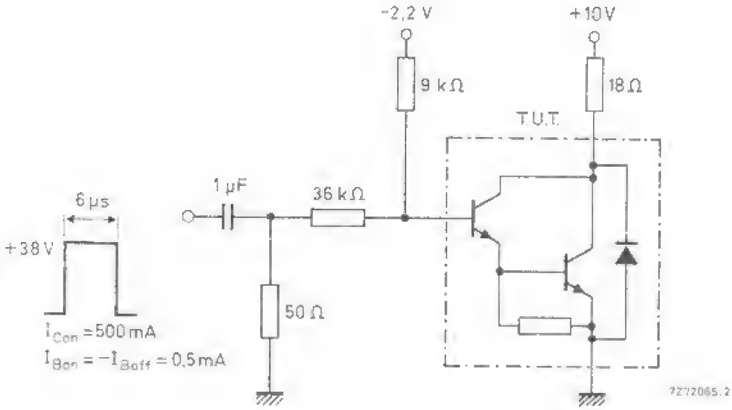


Fig. 2 Test circuit for 500 mA switching.

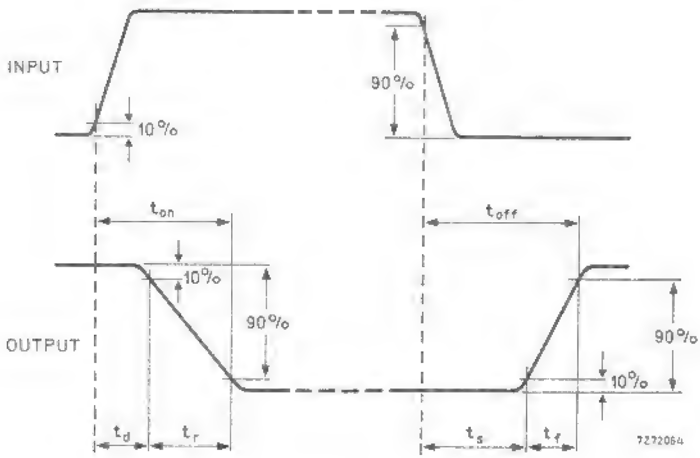


Fig. 3 Switching waveforms.

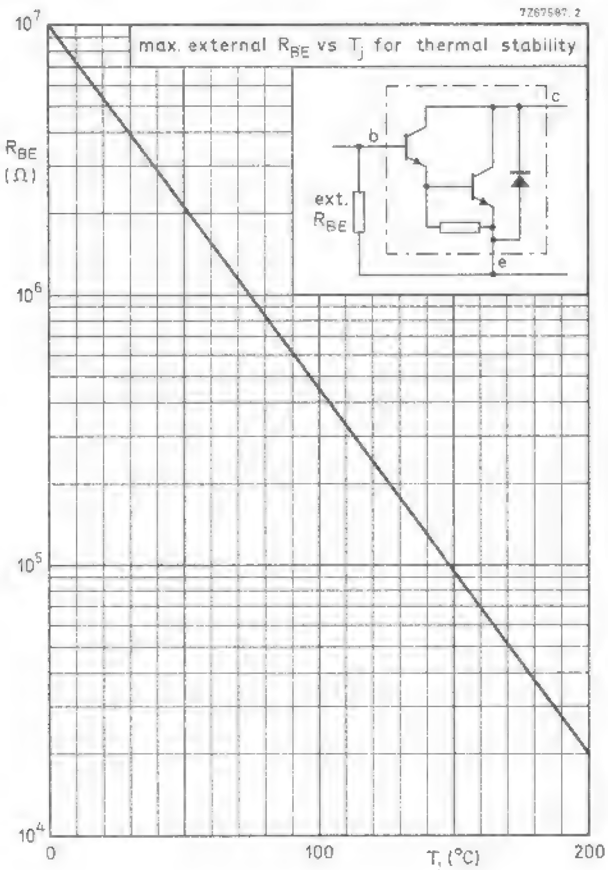

7Z67597.2
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
100
200
T_j (°C)
ext. R_{BE}
b
c
e

Fig. 4.

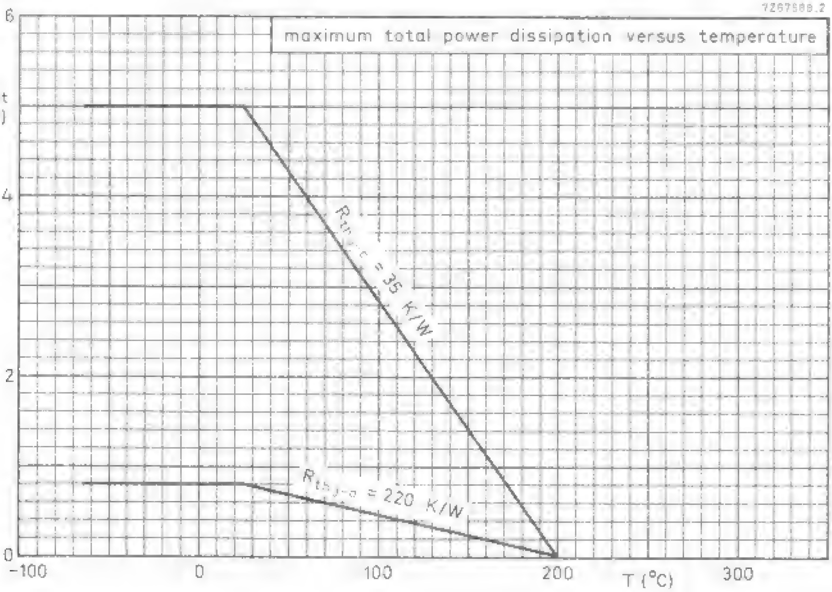

7Z67569.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
$R_{th\,j-c}$ = 35 K/W
$R_{th\,j-a}$ = 220 K/W
−100
0
100
200
300
T (°C)

Fig. 5.

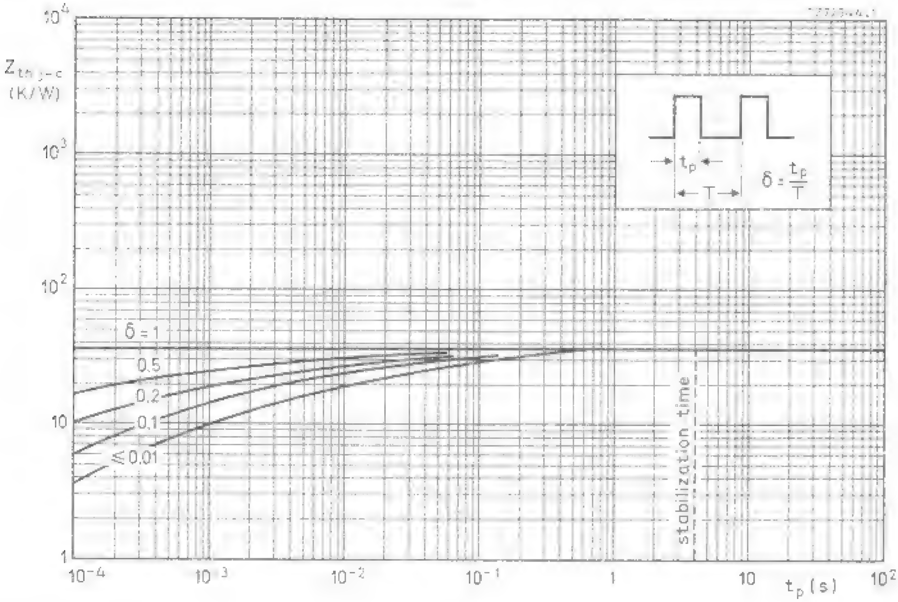

$Z_{th\,j-c}$ (K/W)
10^4
10^3
10^2
10
1
δ = 1
0.5
0.2
0.1
≤ 0.01
t_p
T
$\delta = \frac{t_p}{T}$
stabilization time
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)

Fig. 6.

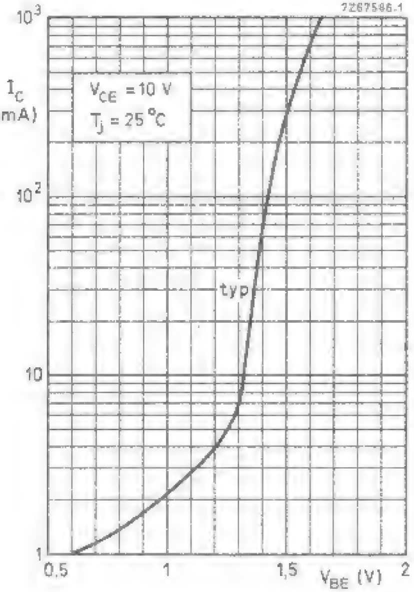


Fig. 7.

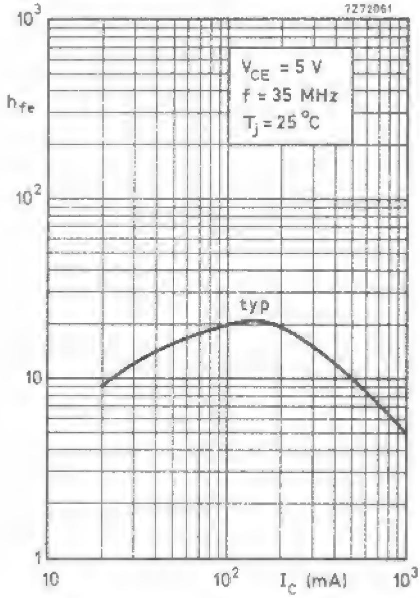


Fig. 8.

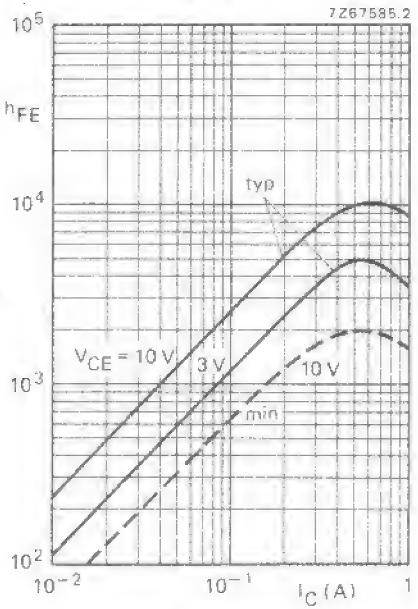


Fig. 9 T_j = 25 °C.

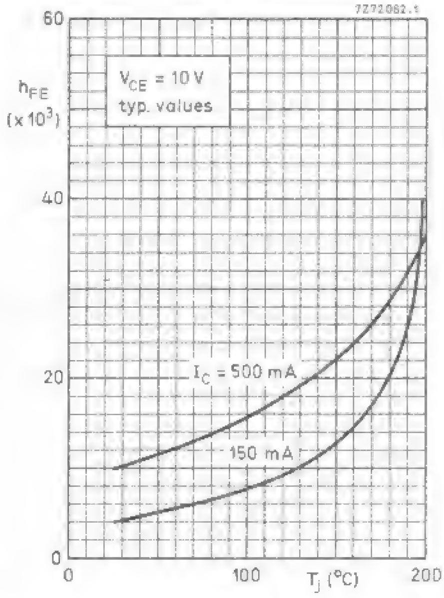


Fig. 10.

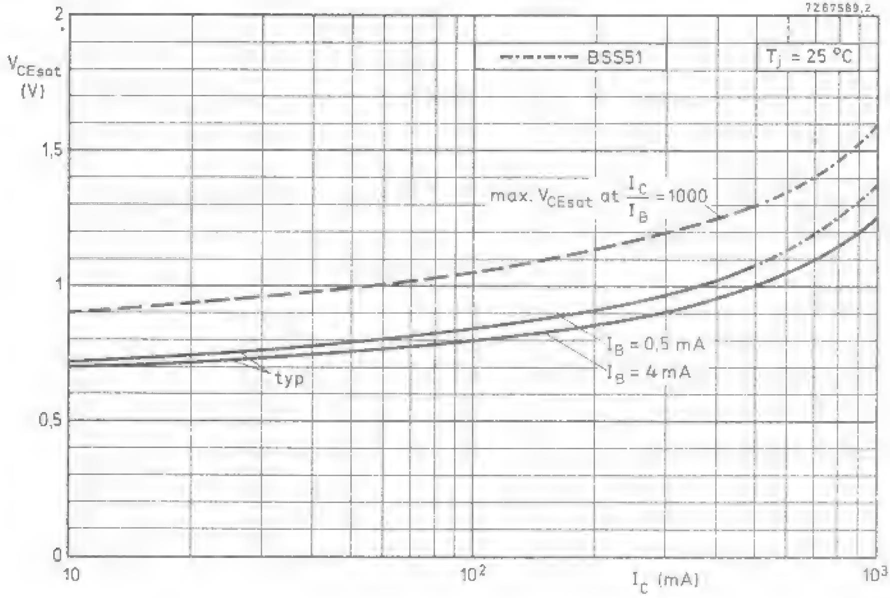

7Z67589.2
V_{CEsat}
(V)
2
1,5
1
0,5
0
BSS51
T_j = 25 °C
max. V_{CEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
10
10^2
I_C (mA)
10^3

Fig. 11.

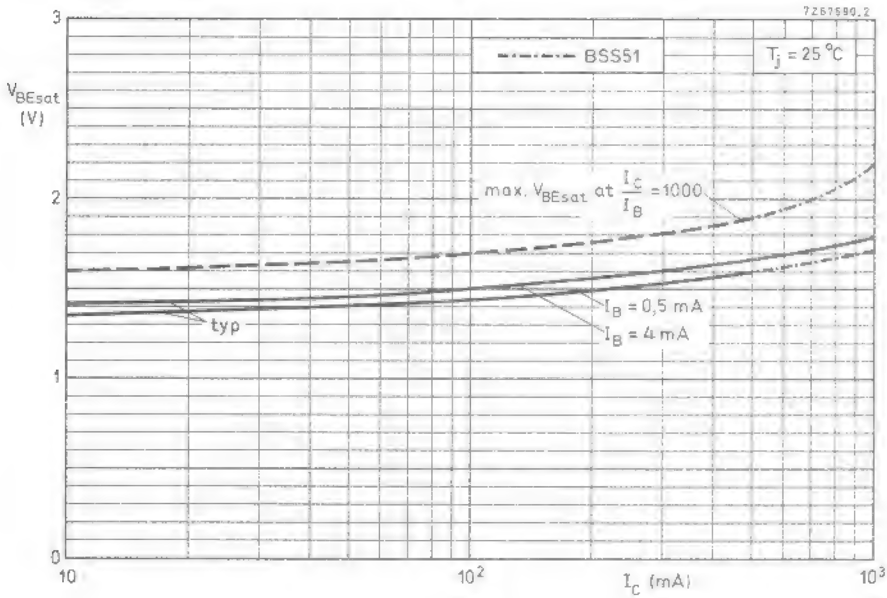

7Z67590.2
V_{BEsat}
(V)
3
2
1
0
BSS51
T_j = 25 °C
max. V_{BEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
10
10^2
I_C (mA)
10^3

Fig. 12.

P-N-P DARLINGTON TRANSISTORS

Silicon planar transistors in TO-39 metal envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

N-P-N complements are the BSS50, BSS51 and BSS52.

QUICK REFERENCE DATA

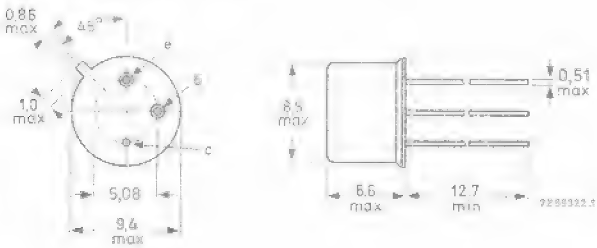
			BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)	$-V_{CER}$	max.	45	60	80	V
Collector current (d.c.)	$-I_C$	max.		1,0		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Collector-emitter saturation voltage						
$-I_C$ = 1,0 A; $-I_B$ = 1,0 mA BSS61	$-V_{CEsat}$	<		1,6		V
$-I_C$ = 1,0 A; $-I_B$ = 4,0 mA BSS60; BSS62	$-V_{CEsat}$	<		1,6		V
D.C. current gain						
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>		2000		
Turn-off time when switched from $-I_{Con}$ = 500 mA; $-I_{Bon}$ = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA	t_{off}	typ.		1,5		μs

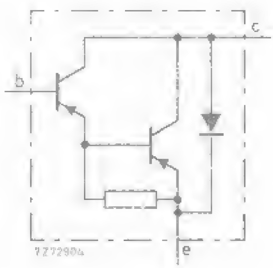
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case





Maximum lead diameter is guaranteed only for 12,7 mm

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-074, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)	$-V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0	5,0	5,0	V

Collector current (d.c.)	$-I_C$	max.	1,0	A
Collector current (peak value)	$-I_{CM}$	max.	2,0	A
Base current (d.c.)	$-I_B$	max.	0,1	A
Total power dissipation				
up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Storage temperature	T_{stg}		−65 to + 200	°C
Junction temperature *	T_j	max.	200	°C

THERMAL RESISTANCE *

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current					
$I_E = 0; -V_{CB} = 45$ V	BSS60	$-I_{CBO}$	<	50	nA
$I_E = 0; -V_{CB} = 60$ V	BSS61	$-I_{CBO}$	<	50	nA
$I_E = 0; -V_{CB} = 80$ V	BSS62	$-I_{CBO}$	<	50	nA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 4{,}0$ V		$-I_{EBO}$	<	100	nA
Saturation voltages					
$-I_C = 500$ mA; $-I_B = 0{,}5$ mA		$-V_{CEsat}$	<	1,3	V
		$-V_{BEsat}$	<	1,9	V
$-I_C = 500$ mA; $-I_B = 0{,}5$ mA; $T_j = 200\ ^oC$		$-V_{CEsat}$	<	1,3	V
$-I_C = 1{,}0$ A; $-I_B = 1{,}0$ mA	BSS61	$-V_{CEsat}$	<	1,6	V
		$-V_{BEsat}$	<	2,2	V
$-I_C = 1{,}0$ A; $-I_B = 1{,}0$ mA; $T_j = 200\ ^oC$	BSS61	$-V_{CEsat}$	<	1,6	V
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA	BSS60; BSS62	$-V_{CEsat}$	<	1,6	V
		$-V_{BEsat}$	<	2,2	V
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA; $T_j = 200\ ^oC$	BSS60; BSS62	$-V_{CEsat}$	<	1,6	V
D.C. current gain					
$-I_C = 150$ mA; $-V_{CE} = 10$ V		h_{FE}	>	1000	
$-I_C = 500$ mA; $-V_{CE} = 10$ V		h_{FE}	>	2000	
Small-signal current gain at f = 35 MHz					
$-I_C = 500$ mA; $-V_{CE} = 5$ V		h_{fe}	typ.	10	

Switching times (see Figs 2 and 3)

$-I_{Con}$ = 500 mA; $-I_{Bon} = I_{Boff}$ = 0,5 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

$-I_{Con}$ = 1,0 A; $-I_{Bon} = I_{Boff}$ = 1,0 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

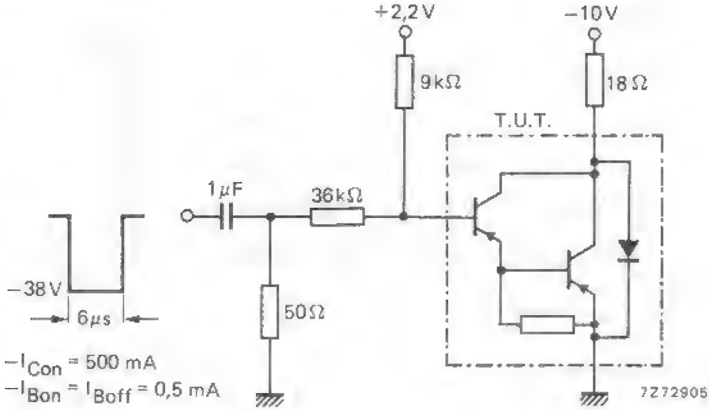


Fig. 2 Test circuit for 500 mA switching.

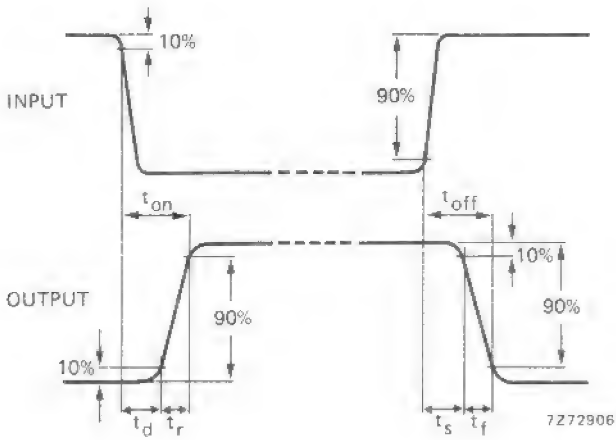


Fig. 3 Switching waveforms.

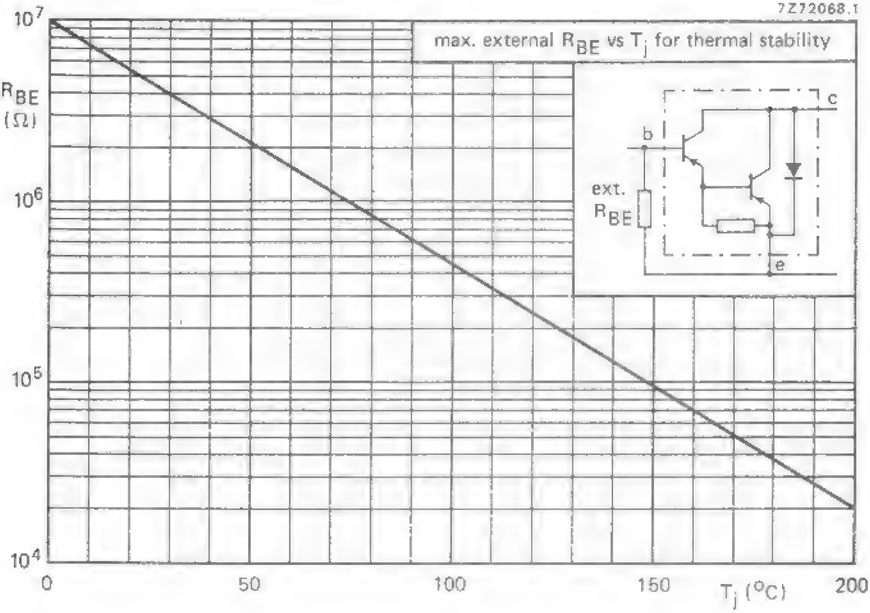

7Z72068.1
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
c
b
ext. R_{BE}
e
0
50
100
150
200
T_j (°C)

Fig. 4.

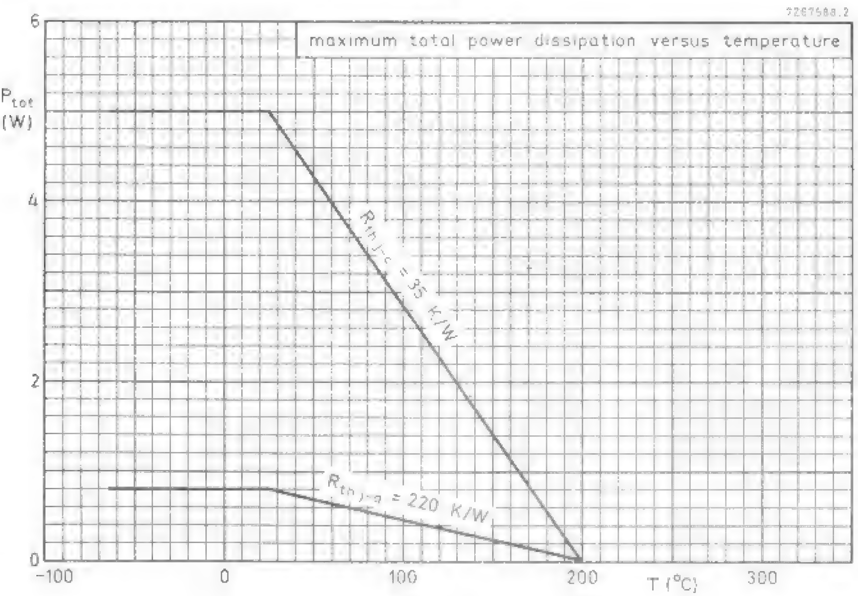

7Z67588.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
$R_{th\ j-c}$ = 35 K/W
$R_{th\ j-a}$ = 220 K/W
−100
0
100
200
300
T (°C)

Fig. 5.

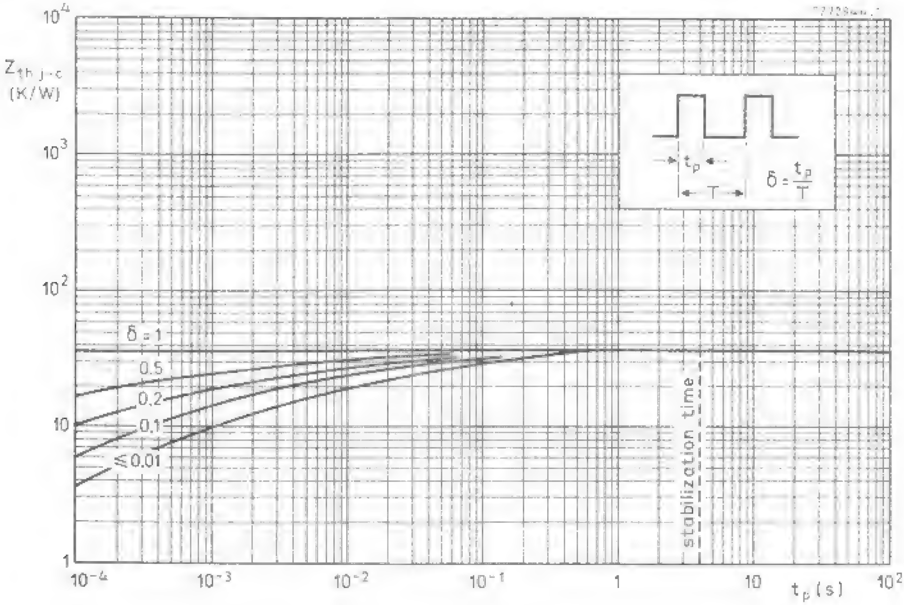


Fig. 6 Thermal impedance as a function of pulse duration.

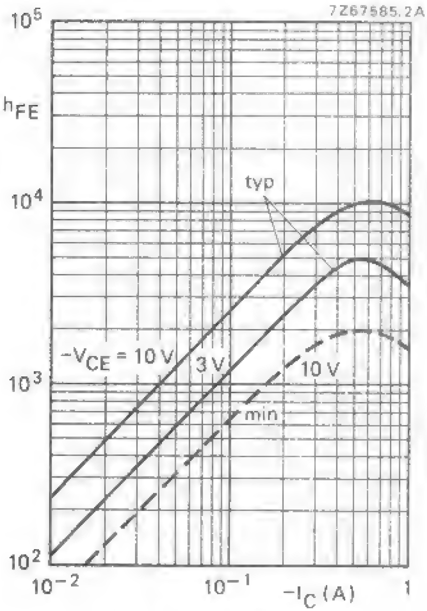


Fig. 7 T_j = 25 °C.

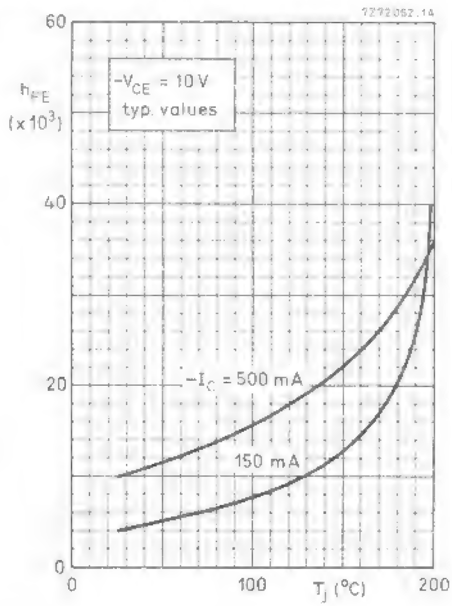


Fig. 8.

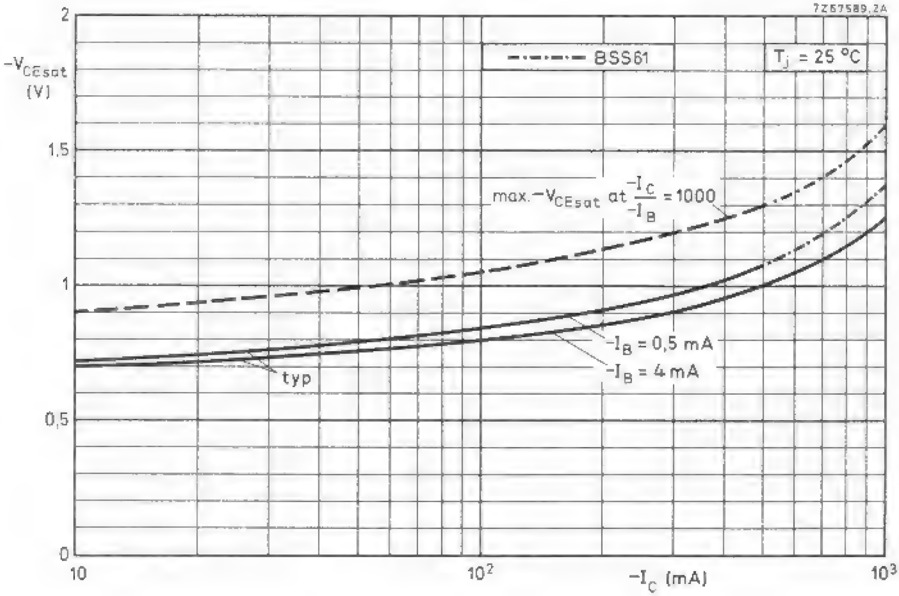

7Z67589.2A
BSS61
T_j = 25 °C
$-V_{CEsat}$ (V)
max. $-V_{CEsat}$ at $\frac{-I_C}{-I_B}$ = 1000
$-I_B$ = 0,5 mA
$-I_B$ = 4 mA
typ
$-I_C$ (mA)

Fig. 9.

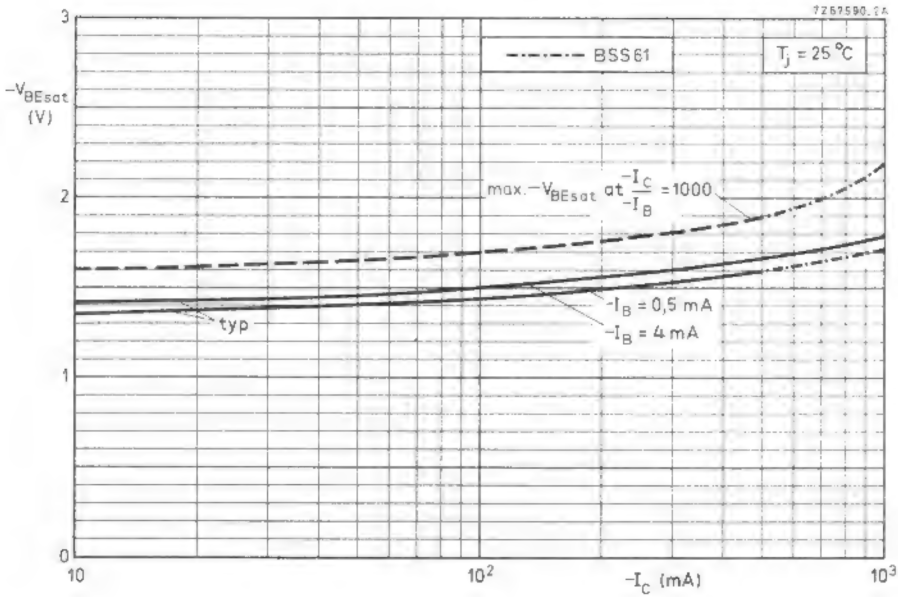

7Z67590.2A
BSS61
T_j = 25 °C
$-V_{BEsat}$ (V)
max. $-V_{BEsat}$ at $\frac{-I_C}{-I_B}$ = 1000
$-I_B$ = 0,5 mA
$-I_B$ = 4 mA
typ
$-I_C$ (mA)

Fig. 10.

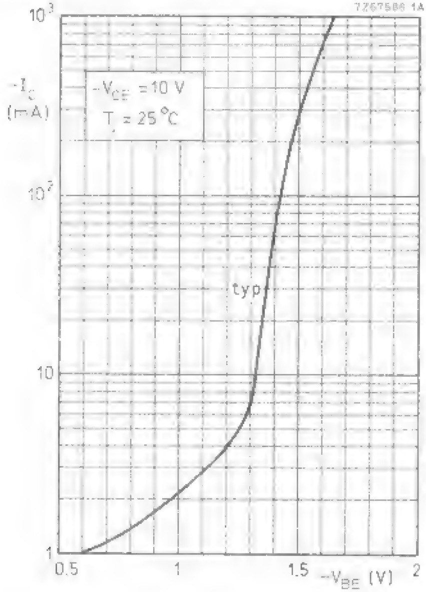

7Z67586.1A
$-I_C$ (mA)
$-V_{CE}$ = 10 V
T_j = 25 °C
typ
10^3
10^2
10
1
0.5
1
1.5
$-V_{BE}$ (V)
2

Fig. 11.

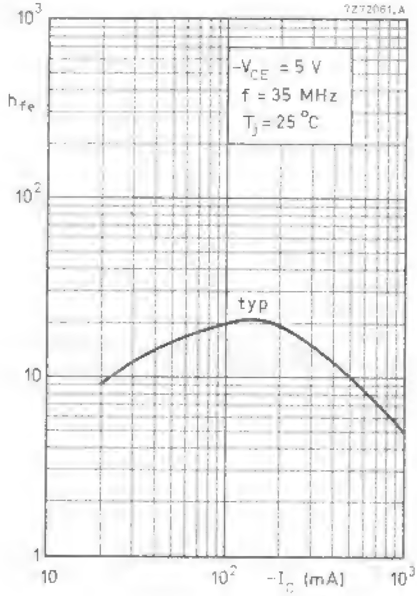

7Z72061.A
h_{fe}
$-V_{CE}$ = 5 V
f = 35 MHz
T_j = 25 °C
typ
10^3
10^2
10
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 12.

HIGH-VOLTAGE P-N-P TRANSISTOR

Silicon planar epitaxial transistor in a plastic TO-92 variant. It is intended for anode switching in dynamically driven numerical indicator tubes and as general purpose switching device.

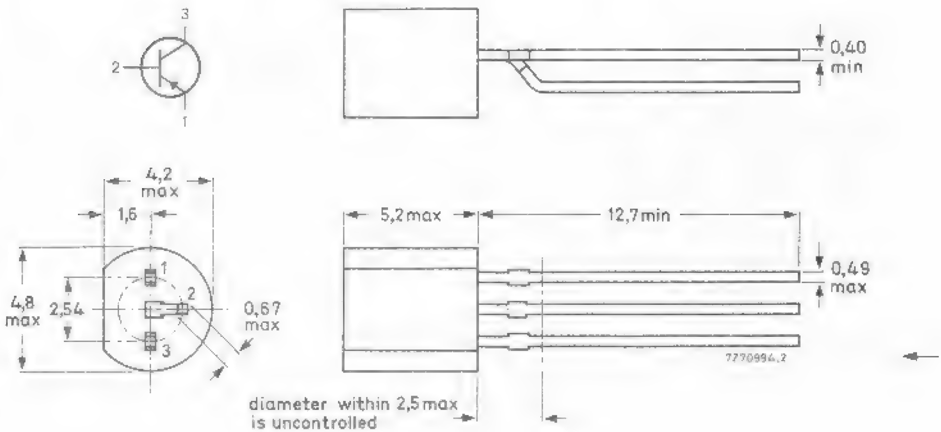
QUICK REFERENCE DATA

Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	max.	110 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	100 V
Collector current (d.c.)	$-I_C$	max.	100 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
Junction temperature	T_j	max.	150 °C
D.C. current gain at T_j = 25 °C $-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30
Transition frequency at f = 35 MHz $-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50 MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	110	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	max.	110	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	V

Current

Collector current (d.c.)	$-I_C$	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}	−65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; $-V_{CB}$ = 100 V; T_j = 70 °C	$-I_{CBO}$	<	10	μA

Saturation voltages

$-I_C$ = 25 mA; $-I_B$ = 2,5 mA	$-V_{CEsat}$	<	250	mV
	$-V_{BEsat}$	<	900	mV

D.C. current gain

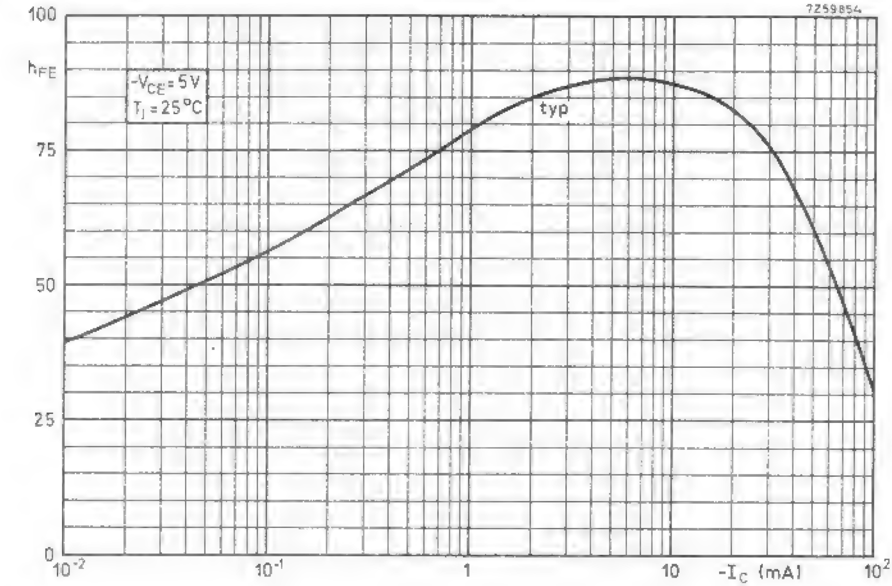
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	

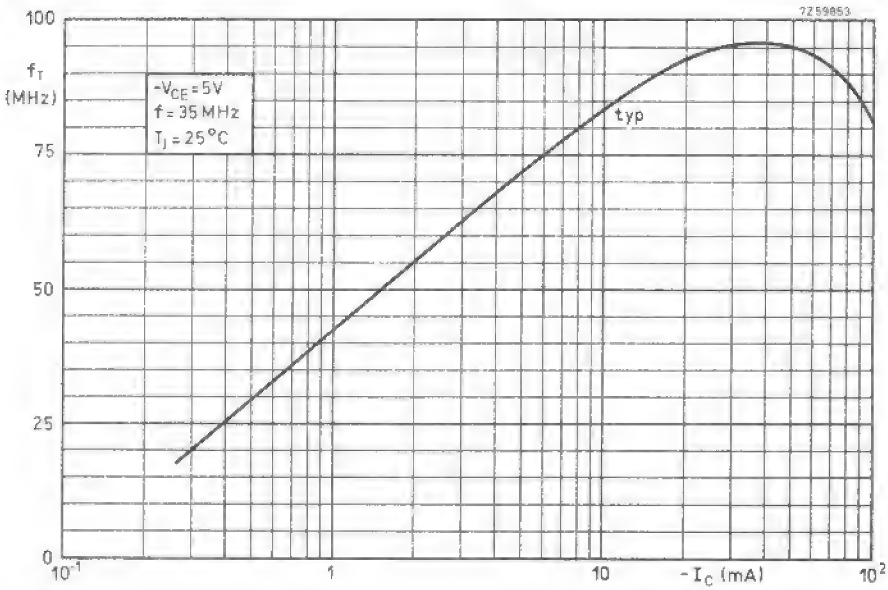
Collector capacitance at f = 1 MHz

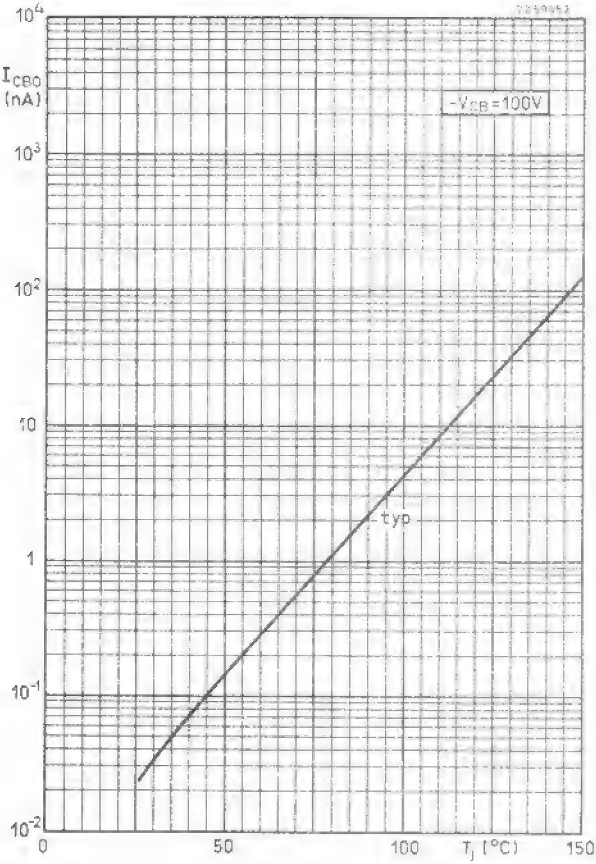
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	5	pF

Transition frequency at f = 35 MHz

$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz


7Z59854
100
h_{FE}
$-V_{CE} = 5\,V$
$T_j = 25\,^\circ C$
typ
75
50
25
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59853
100
f_T
(MHz)
$-V_{CE} = 5\,V$
f = 35 MHz
$T_j = 25\,^\circ C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z69952
$-I_{CBO}$ (nA)
$-V_{CB}$=100V
typ
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
T_j (°C)
150

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes with the collector connected to the case. These transistors are intended for general industrial applications.

QUICK REFERENCE DATA

			BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	V
Collector current (d.c.)	$-I_C$	max.		1,0		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz						
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>		50		MHz

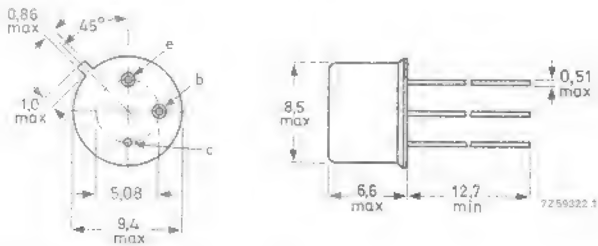
		BSV15–6 BSV16–6 BSV17–6	BSV15–10 BSV16–10 BSV17–10	BSV15–16 BSV16–16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	40–100	63–160	100–250

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-131, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

			BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	V
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	40	60	90	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	1.0	A
Base current (d.c.)	$-I_B$	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	5.0	W
up to T_{mb} = 50 °C	P_{tot}	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	30	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

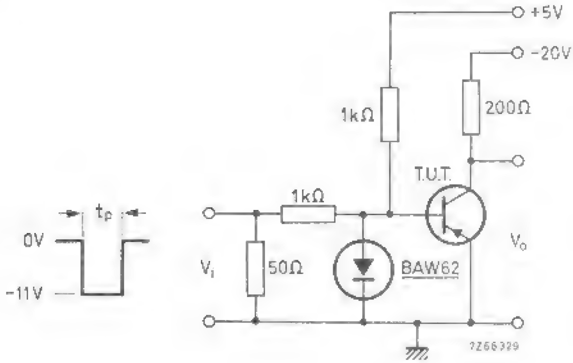
			BSV15	BSV16	BSV17	
Collector cut-off currents						
$V_{BE} = 0$; $-V_{CE} = 40$ V	$-I_{CES}$	<	100	–	–	nA
$V_{BE} = 0$; $-V_{CE} = 40$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	50	–	–	µA
$V_{BE} = 0$; $-V_{CE} = 60$ V	$-I_{CES}$	<	–	100	–	nA
$V_{BE} = 0$; $-V_{CE} = 60$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	50	–	µA
$V_{BE} = 0$; $-V_{CE} = 80$ V	$-I_{CES}$	<	–	–	100	nA
$V_{BE} = 0$; $-V_{CE} = 80$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	–	50	µA
$-V_{BE} = 0,2$ V; $-V_{CE} = 40$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	50	–	–	µA
$-V_{BE} = 0,2$ V; $-V_{CE} = 60$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	50	–	µA
$-V_{BE} = 0,2$ V; $-V_{CE} = 80$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	–	50	µA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	50	50	50	nA
Breakdown voltages						
$I_B = 0$; $-I_C = 50$ mA; $t_p = 200$ µs; $\delta = 0,01$	$-V_{(BR)CEO}$	>	40	60	80	V
$V_{BE} = 0$; $-I_C = 10$ µA	$-V_{(BR)CES}$	>	40	60	90	V
$I_C = 0$; $-I_E = 10$ µA	$-V_{(BR)EBO}$	>	5	5	5	V

Base-emitter voltage				
$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,0	V
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	0,85	V
			0,7 to 1,4	V
Saturation voltage				
$-I_C = 500$ mA; $-I_B = 25$ mA	$-V_{CEsat}$	<	1,0	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V BSV15; BSV16	C_c	typ.	20	pF
		<	30	pF
$I_E = I_e = 0$; $-V_{CB} = 10$ V BSV17	C_c	typ.	15	pF
		<	25	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	typ.	180	pF
Transition frequency at f = 20 MHz				
$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	50	MHz

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

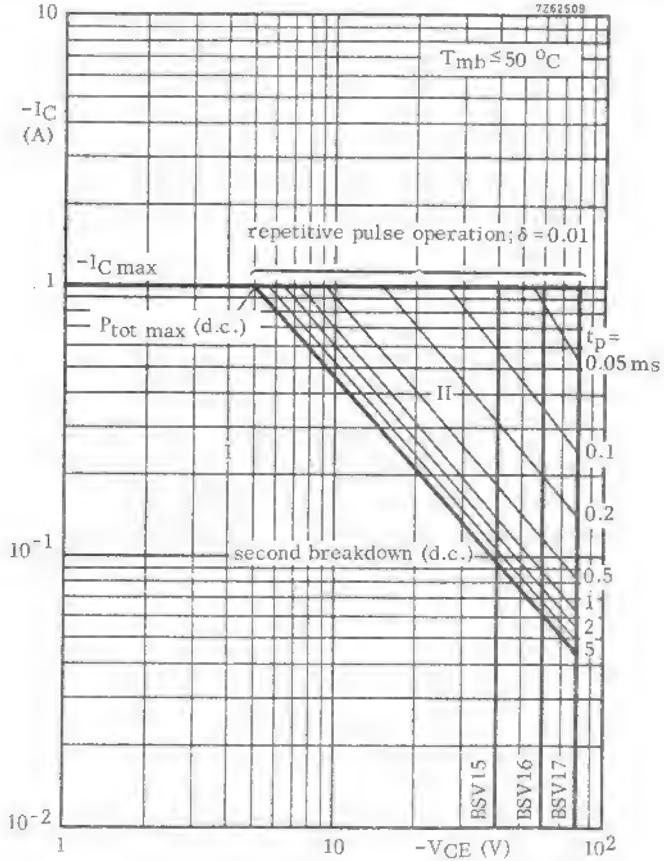
			BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16	
D.C. current gain						
$-I_C$ = 0.1 mA; $-V_{CE}$ = 1 V	h_{FE}	>	15	20	30	
		typ.	44	75	120	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	63	100	160	
			40 to 100	63 to 160	100 to 250	
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	25	35	
		typ.	40	55	85	
h parameter at f = 1 kHz						
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V						
Small signal current gain	h_{fe}	>		20		
Switching times						
Turn-on time						
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA	t_{on}	<		500		ns
Turn-off time						
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA						
Storage time	t_s	<		500		ns
Fall time	t_f	<		150		ns

Test circuit:



Pulse generator:
Pulse duration $t_p \geq 10\ \mu s$
Rise time $t_r \leq 15$ ns
Fall time $t_f \leq 15$ ns
Source impedance $R_S = 50\ \Omega$

Oscilloscope:
Rise time $\leq$ 15 ns
Input impedance $\geq$ 100 kΩ



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

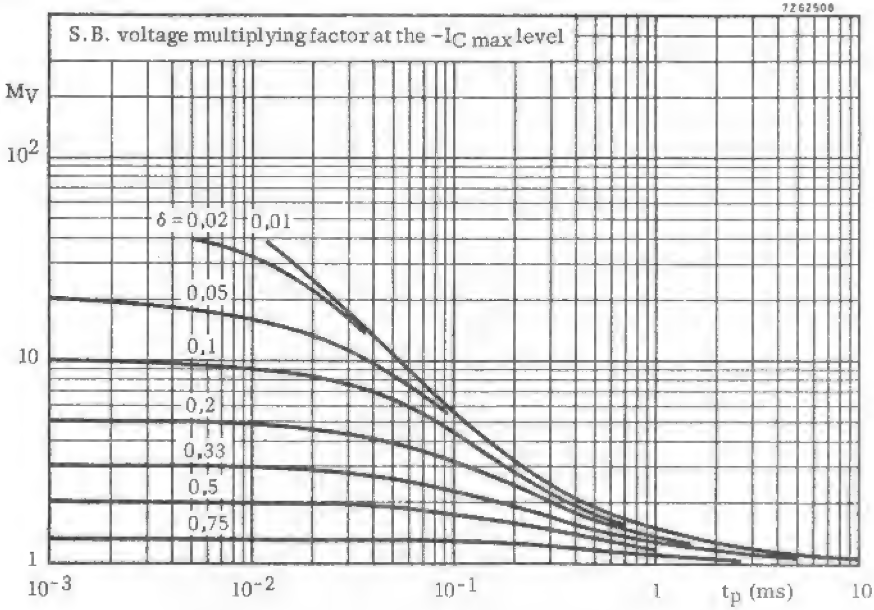

7Z62508
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
M_V
10^2
10
1
$\delta = 0,02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 4.

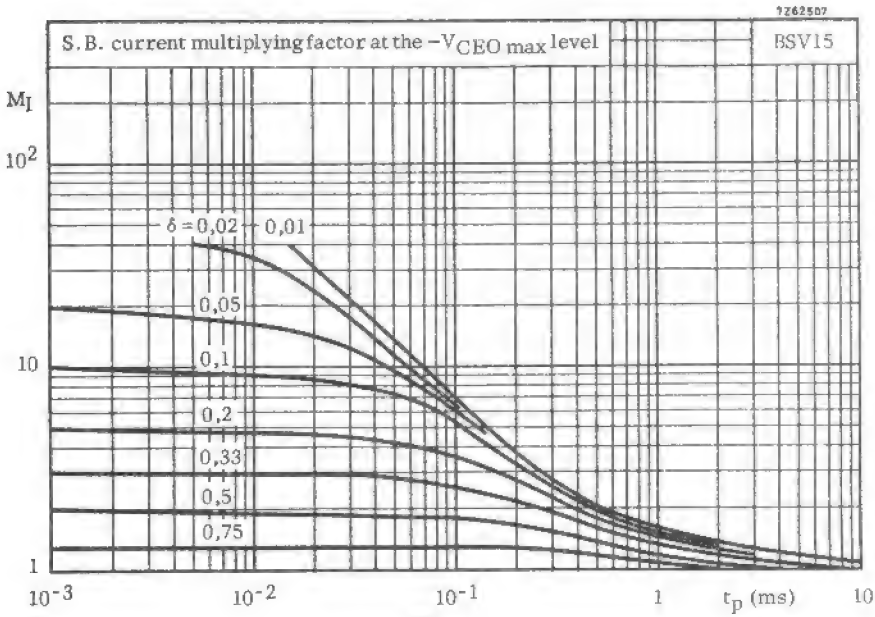

7Z62507
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV15
M_I
10^2
10
1
$\delta = 0,02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 5.

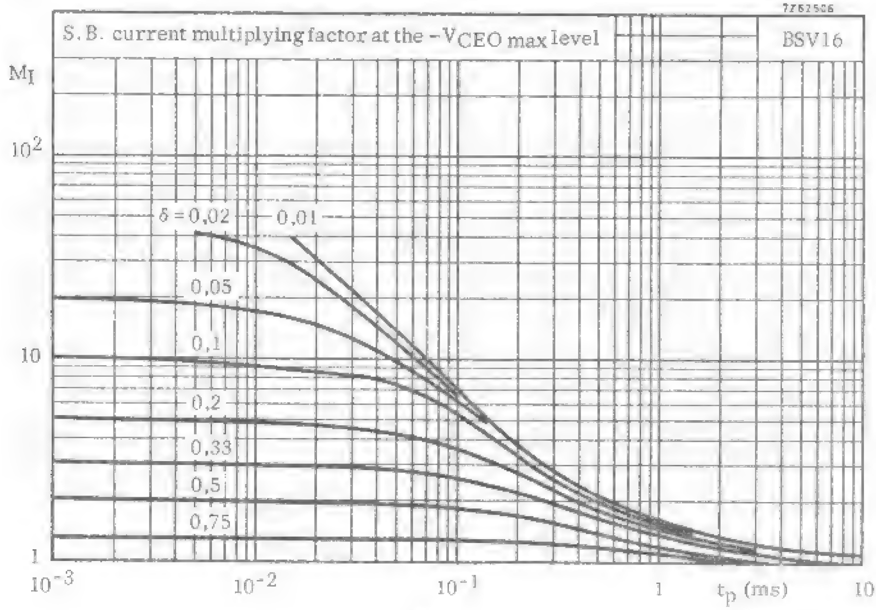

7Z62506
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV16
M_I
10^2
10
1
$\delta = 0{,}02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 6.

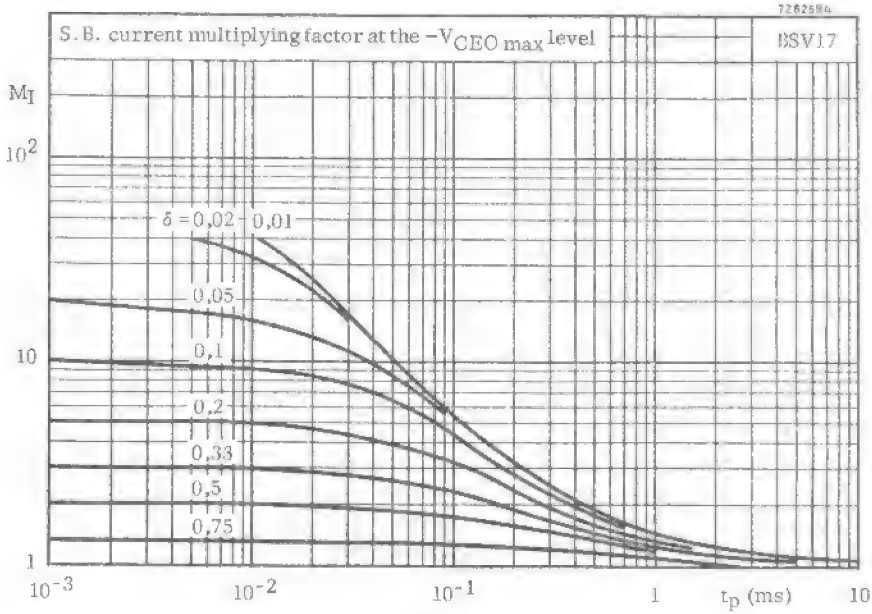
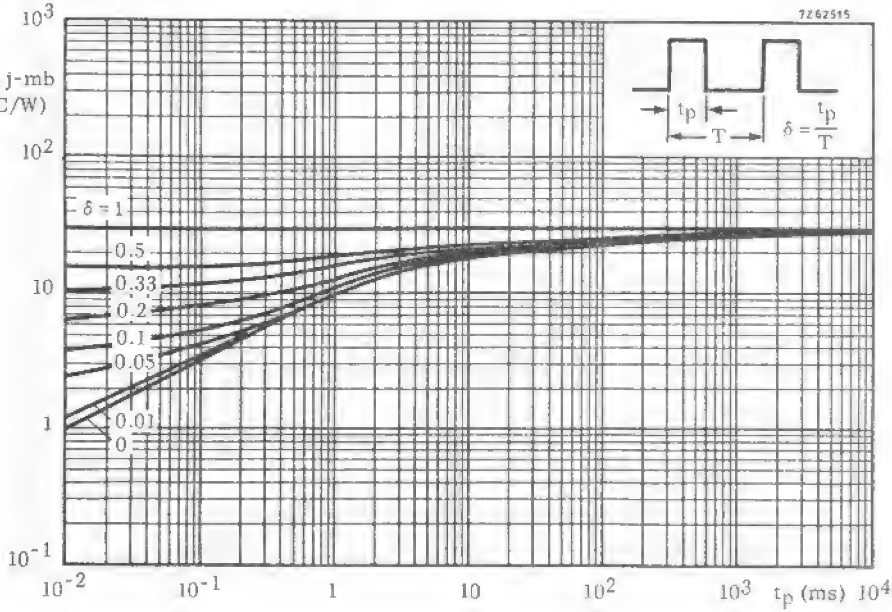
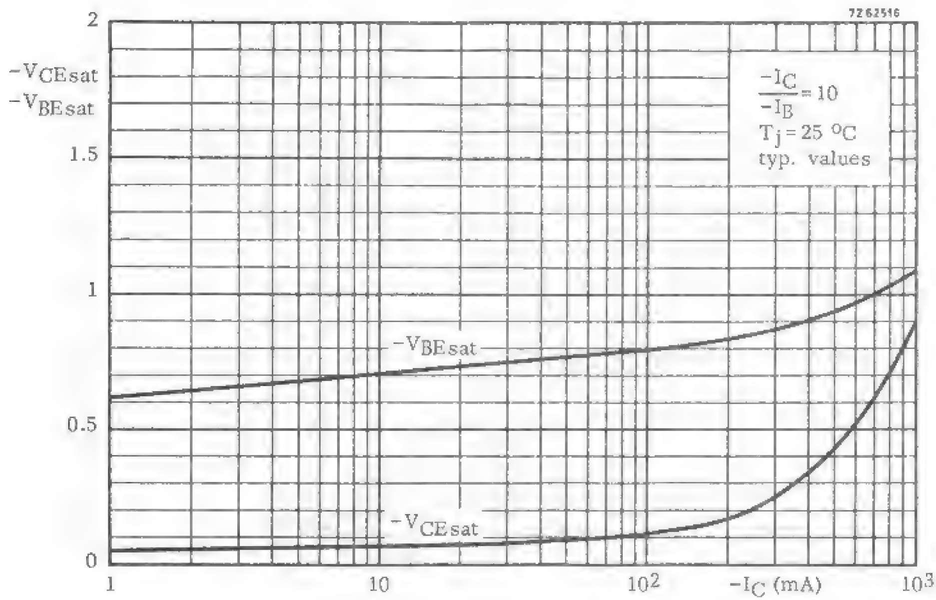
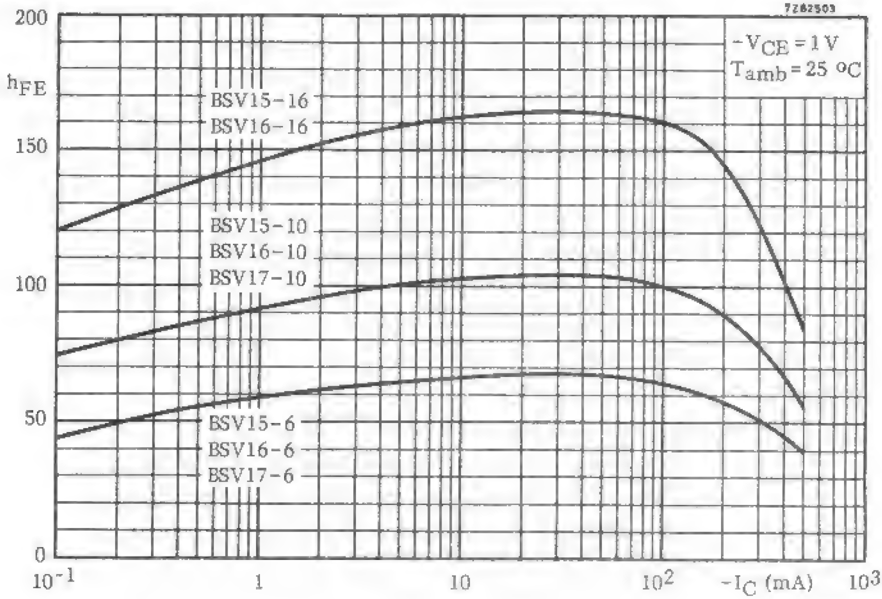
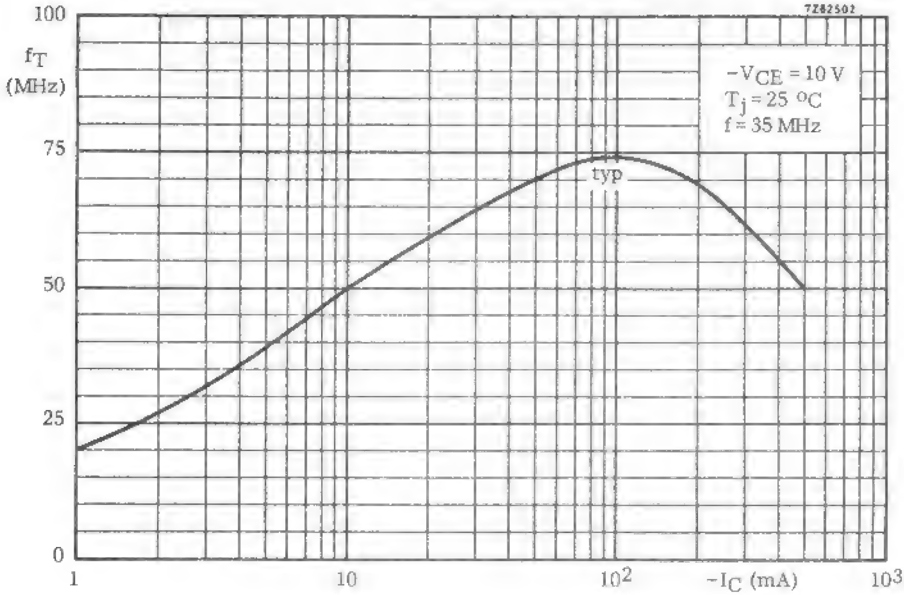

7Z62504
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV17
M_I
10^2
10
1
$\delta = 0{,}02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

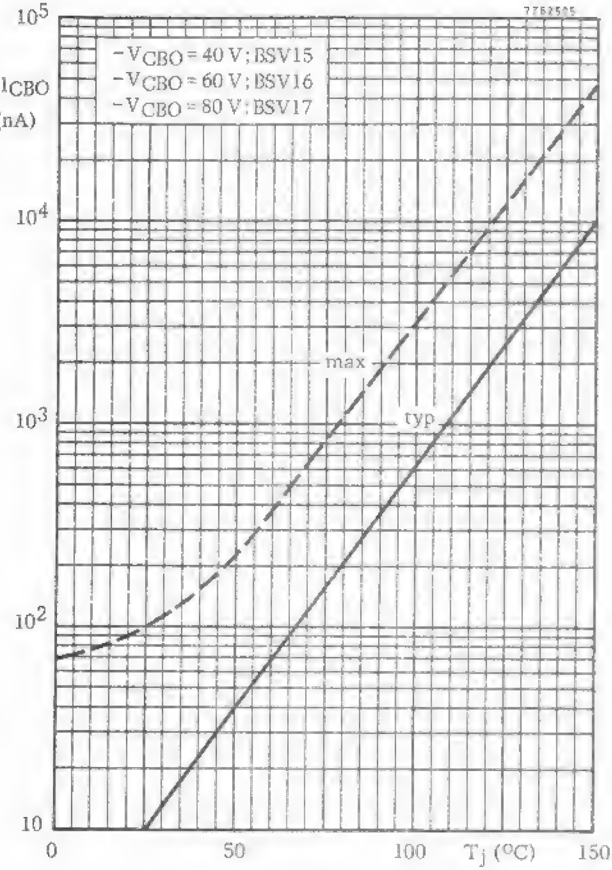
Fig. 7.


7Z62515
$Z_{th\ j\text{-}mb}$ ($^{o}C/W$)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0.5
0.33
0.2
0.1
0.05
0.01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4


7Z62516
$-V_{CEsat}$
$-V_{BEsat}$
2
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25\ ^{o}C$
typ. values
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$ (mA)
10^3


7Z82503
200
h_{FE}
150
100
50
0
$-V_{CE} = 1\ V$
$T_{amb} = 25\ ^oC$
BSV15-16
BSV16-16
BSV15-10
BSV16-10
BSV17-10
BSV15-6
BSV16-6
BSV17-6
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3


7Z82502
100
f_T
(MHz)
75
50
25
0
$-V_{CE} = 10\ V$
$T_j = 25\ ^oC$
f = 35 MHz
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z62505
$-V_{CBO}$ = 40 V; BSV15
$-V_{CBO}$ = 60 V; BSV16
$-V_{CBO}$ = 80 V; BSV17
$-I_{CBO}$
(nA)
10^5
10^4
10^3
10^2
10
max
typ
0
50
100
T_j (°C)
150

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-39 metal envelope primarily intended for use as a print hammer drive. It has good high current saturation characteristics.

QUICK REFERENCE DATA

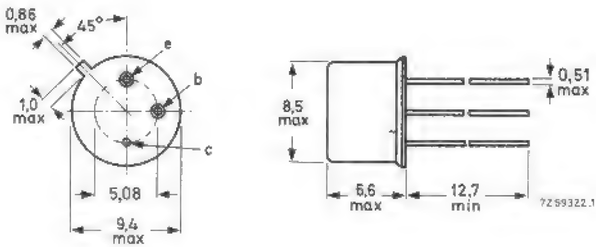
Collector-base voltage (open emitter)	V_{CBO}	max.	100 V
Collector-emitter voltage (open base)	V_{CEO}	max.	60 V
Collector current (peak value)	I_{CM}	max.	5,0 A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0 W
Junction temperature	T_j	max.	175 °C
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	40
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.	100 MHz
Turn-off time when switched from I_{Con} = 5 A; I_{Bon} = 0,5 A to cut-off with $-I_{Boff}$ = 0,5 A	t_{off}	<	1,2 μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-025, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage ($R_{BE} \le 50\ \Omega$)	V_{CER}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	2,0	A
Collector current (peak value)	I_{CM}	max.	5,0	A
Base current (d.c.)	I_B	max.	1,0	A

Power dissipation

Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0	W

Temperatures

Storage temperature	T_{stg}	−55 to +175		°C
Junction temperature	T_j	max.	175	°C

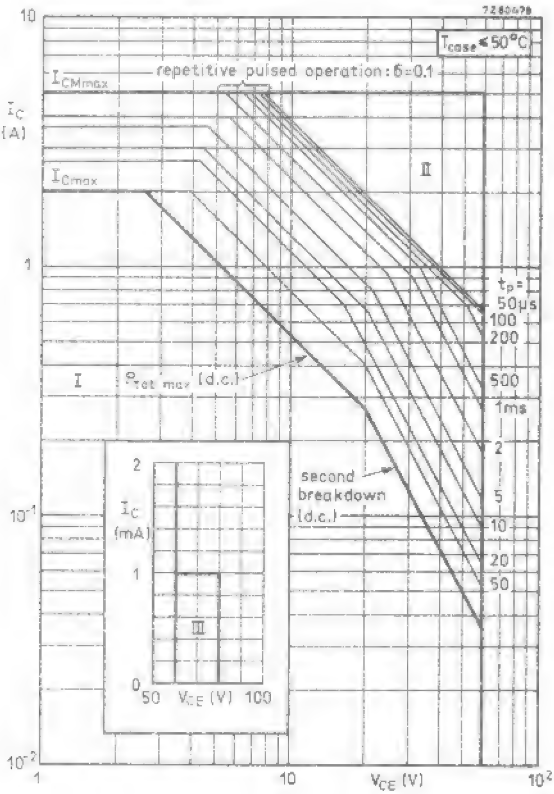
THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	25	°C/W

CHARACTERISTICS

$T_j = 25\ ^oC$

Collector cut-off current $I_E = 0$; $V_{CB} = 60\ V$	I_{CBO}	$<$	10 μA
Emitter cut-off current $I_C = 0$; $V_{EB} = 4\ V$	I_{EBO}	$<$	10 μA
Saturation voltages $I_C = 5\ A$; $I_B = 0{,}5\ A$	V_{CEsat}	$<$	1,0 V
	V_{BEsat}	$<$	1,8 V
D.C. current gain $I_C = 2\ A$; $V_{CE} = 2\ V$	h_{FE}	$>$	40
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; $V_{CB} = 10\ V$	C_c	$<$	80 pF
Transition frequency at f = 35 MHz $I_C = 0{,}5\ A$; $V_{CE} = 5\ V$	f_T	typ.	100 MHz
Switching times $I_{Con} = 5\ A$; $I_{Bon} = -I_{Boff} = 0{,}5\ A$ $-V_{BEoff} = 2\ V$ turn-on time	t_{on}	$<$	0,6 μs
turn-off time	t_{off}	$<$	1,2 μs

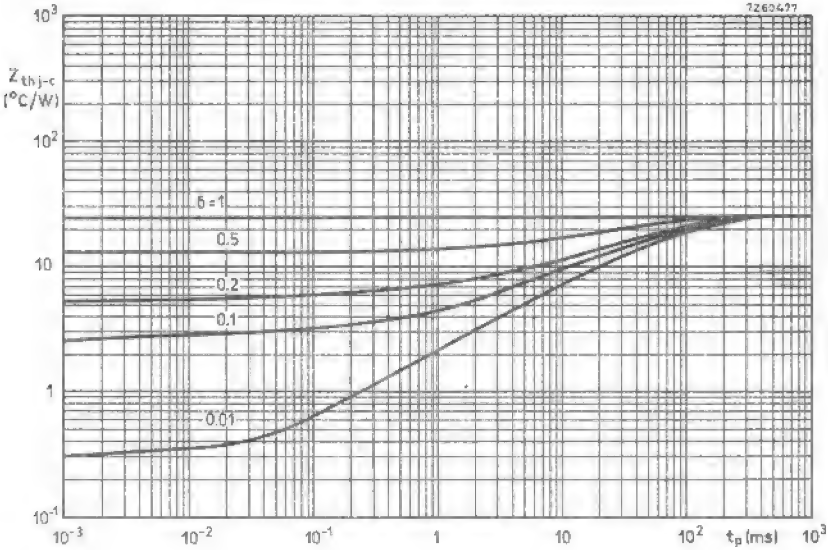


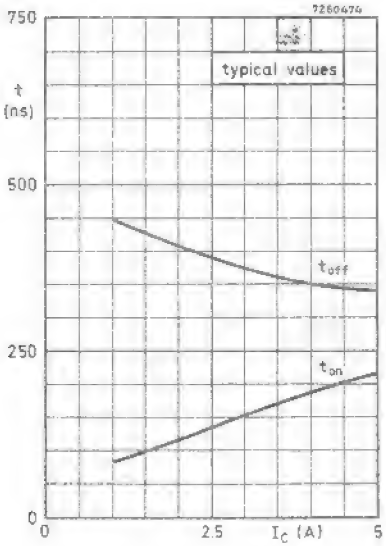
Safe Operating Area

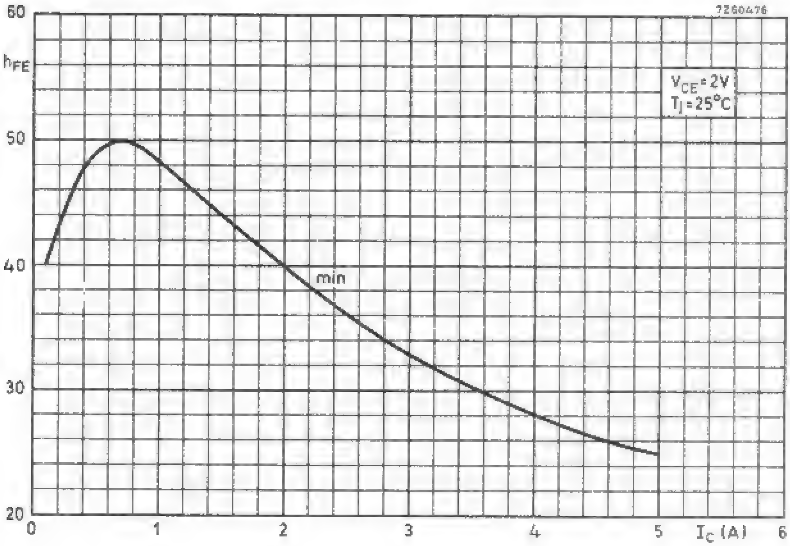
I Region of permissible d.c. operation

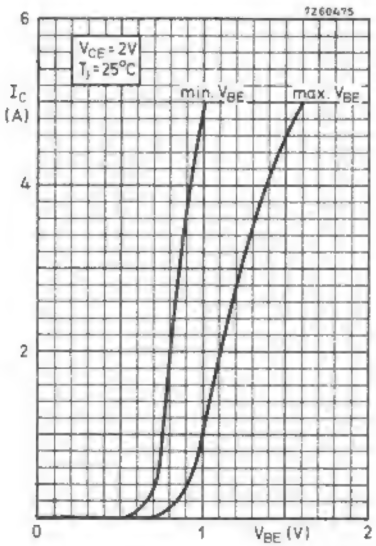
II Permissible extension for repetitive pulsed operation

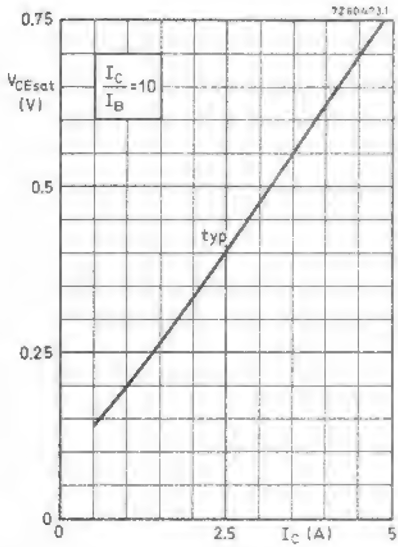
III D.C. operation in this region is allowable, provided $R_{BE} \leq 50\ \Omega$


7Z60477
$Z_{th\,j\text{-}c}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
typical values
t (ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
h_{FE}
V_{CE} = 2V
T_j = 25°C
50
40
min
30
20
0
1
2
3
4
5
I_C (A)
6


7Z60475
6
V_{CE} = 2V
T_j = 25°C
I_C
(A)
min. V_{BE}
max. V_{BE}
4
2
0
1
V_{BE} (V)
2


0.75
V_{CEsat}
(V)
$\frac{I_C}{I_B}$ = 10
0.5
typ
0.25
0
0
2.5
I_C (A)
5

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors primarily intended for general purpose industrial and switching applications.

QUICK REFERENCE DATA

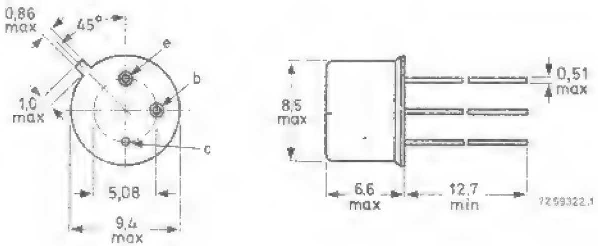
			BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	120	150	V
Collector current (peak value)	I_{CM}	max.		2		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Collector-emitter saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<		400		mV
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		30		
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>		30		
Transition frequency at f = 35 MHz I_C = 100 mA; V_{CE} = 20 V	f_T	typ.		130		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-040, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base) *	V_{CEO}	max.	100	120	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V
Collector current (d.c. or average)	I_C	max.		1		A
Collector current (peak value; $t_p \leq 20$ ms)	I_{CM}	max.		2		A
Total power dissipation up to						
$T_{amb} = 25\ ^oC$	P_{tot}	max.		0,8		W
$T_{case} = 25\ ^oC$	P_{tot}	max.		5,0		W
Storage temperature	T_{stg}			−65 to + 200		^oC
Junction temperature	T_j	max.		200		^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$	=	35	$^oC/W$

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			BSW66A	BSW67A	BSW68A	
Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		100		µA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$	I_{CBO}	<		100		nA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	<		50		µA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 6$ V	I_{EBO}	<		100		µA
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<		100		nA
Collector-emitter breakdown voltage						
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	100	120	150	V
Saturation voltages						
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<		150		mV
	V_{BEsat}	<		900		mV
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<		400		mV
	V_{BEsat}	<		1,1		V
$I_C = 1,0$ A; $I_B = 150$ mA	V_{CEsat}	<		1,0		V
	V_{BEsat}	<		1,4		V

* See Application Information

D.C. current gain			
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30
		typ.	75
I_C = 100 mA; V_{CE} = 5 V	h_{FE}	>	40
		typ.	90
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30
		typ.	80
I_C = 1,0 A; V_{CE} = 5 V	h_{FE}	>	10
		typ.	15
Collector capacitance at f = 1 MHz; $I_E = I_e = 0$; V_{CB} = 10 V	C_c	<	20 pF
Emitter capacitance at f = 1 MHz; $I_C = I_c = 0$; V_{EB} = 0	C_e	<	300 pF
Transition frequency at f = 35 MHz; I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	130 MHz
Turn-on time (see Fig. 2); I_{Con} = 500 mA; I_{Bon} = 50 mA; $-V_{BEoff}$ = 4 V	t_{on}	typ.	0,5 µs
Turn-off time (see Fig. 2); I_{Con} = 500 mA; $I_{Bon} = -I_{Boff}$ = 50 mA	t_{off}	typ.	0,9 µs

Pulse generator:
$t_p \geqslant$ 5 µs
$t_r \leqslant$ 10 ns
$t_f \leqslant$ 10 ns

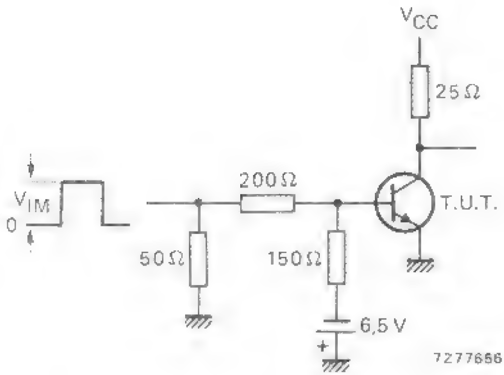


Fig. 2 Test circuit for saturated switching characteristics.
V_{CC} = 13 V; V_{IM} = 21 V.

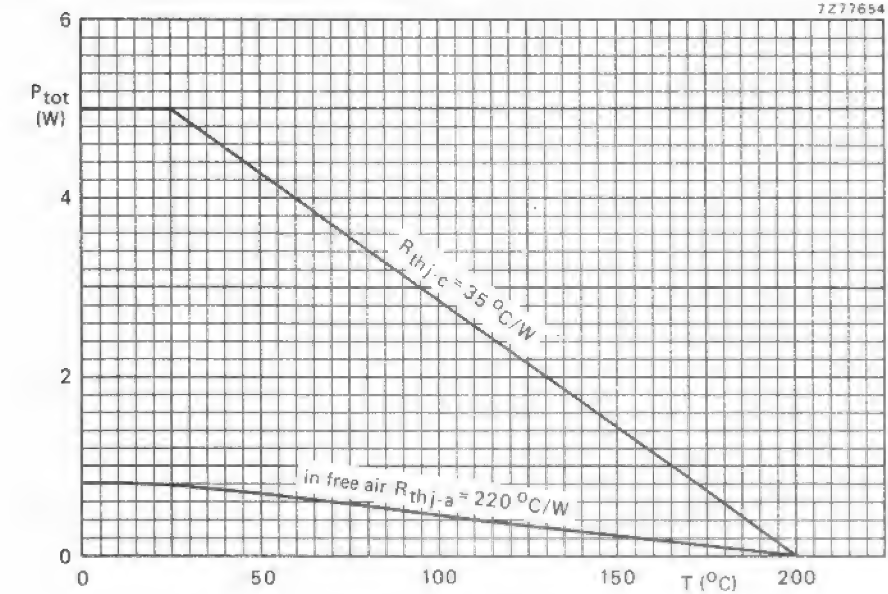


Fig. 3 Maximum permissible power dissipation versus temperature.

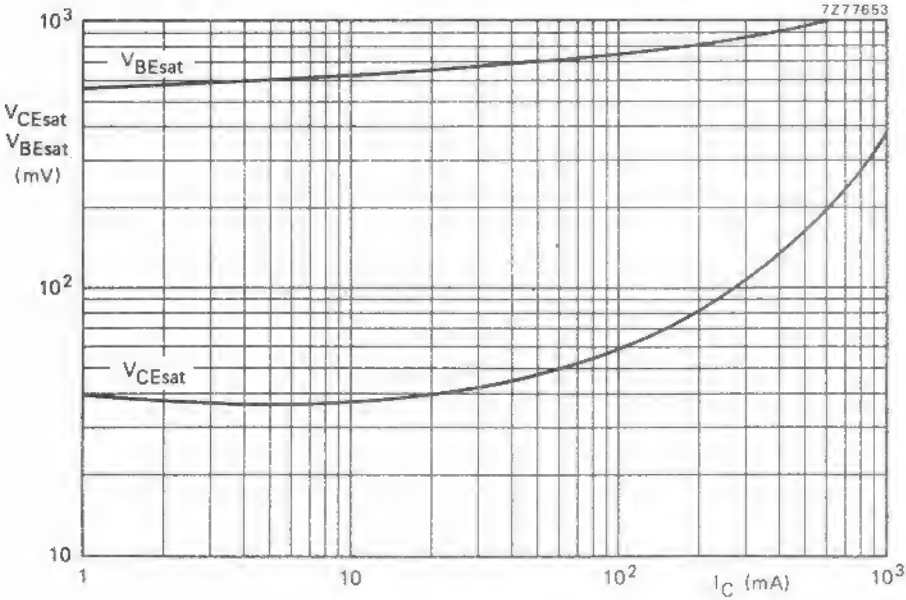


Fig. 4 $I_C/I_B = 10$; $T_j = 25$ °C; typical values.

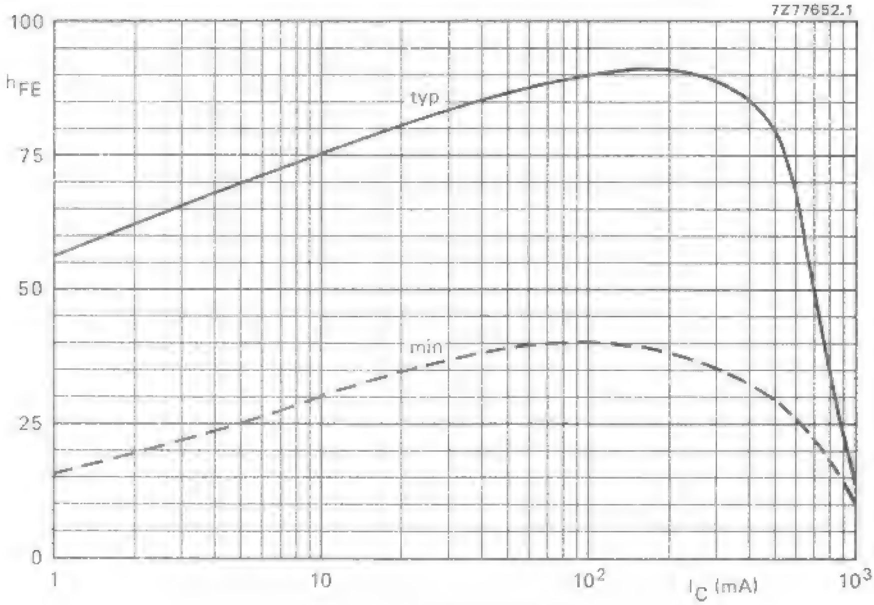


Fig. 5 V_{CE} = 5 V; T_j = 25 °C.

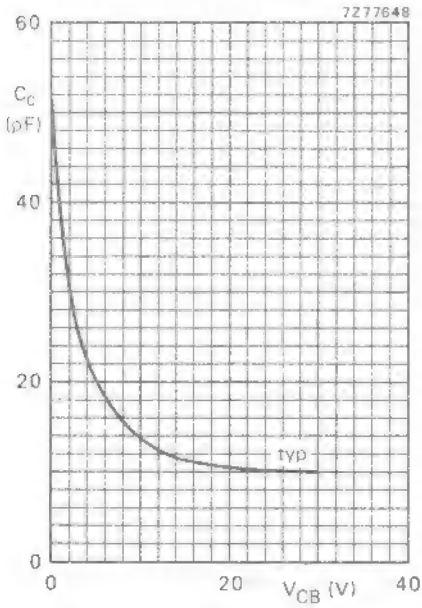


Fig. 6 $I_E = I_e = 0$; T_j = 25 °C.

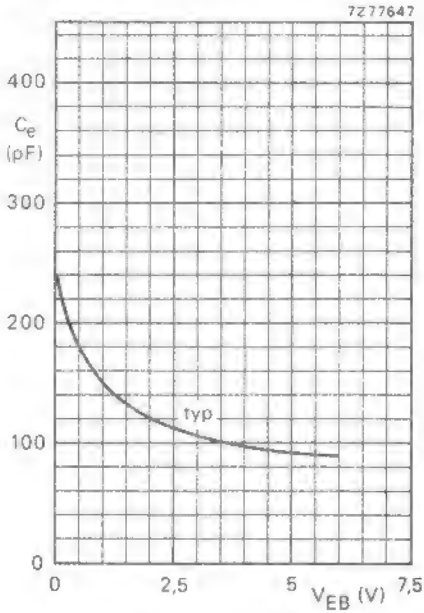


Fig. 7 $I_C = I_c = 0$; T_j = 25 °C.

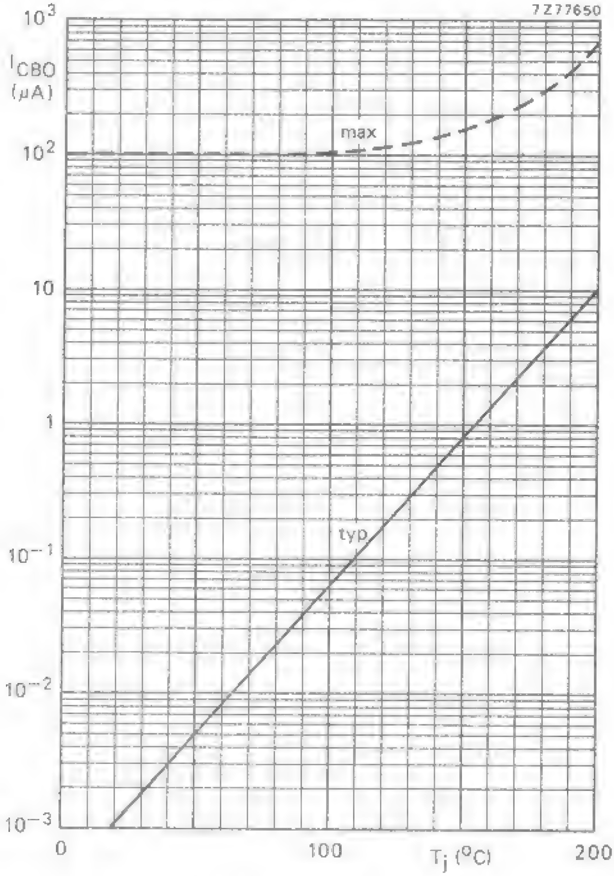


Fig. 8 $V_{CB} = V_{CBOmax}$.

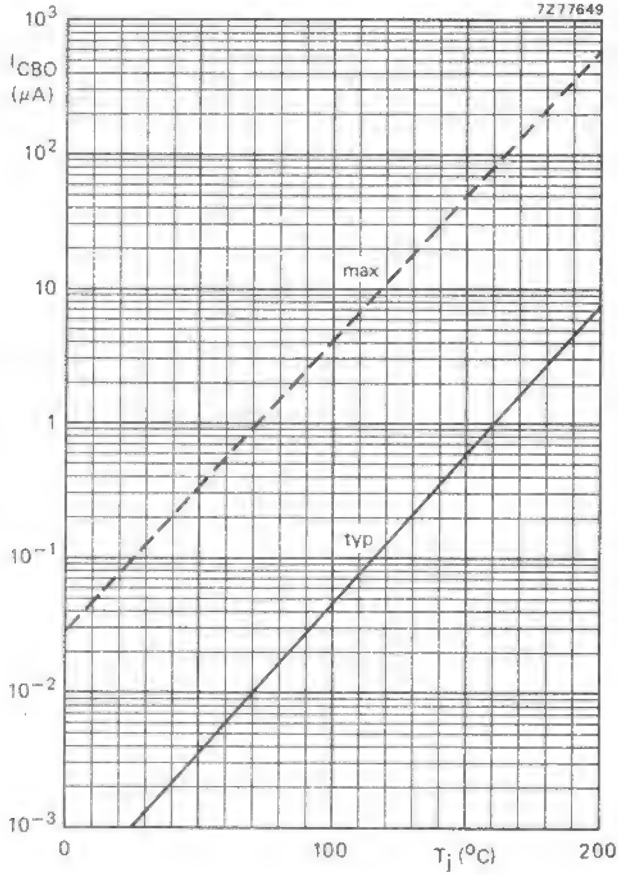


Fig. 9 $V_{CB} = \frac{1}{2}V_{CBOmax}$.

APPLICATION INFORMATION

Clamped inductive load turn-off capability

With a base-emitter resistance of $\geq 330\ \Omega$, i.e. an available reverse base current of ≤ 2 mA, and the maximum permitted clamping voltage i.e. the rated V_{CEOmax}, the transistor will be free from second-breakdown effects when turning off from collector current values up to the rated I_{CMmax} of 2 A. See Figs 10 and 11.

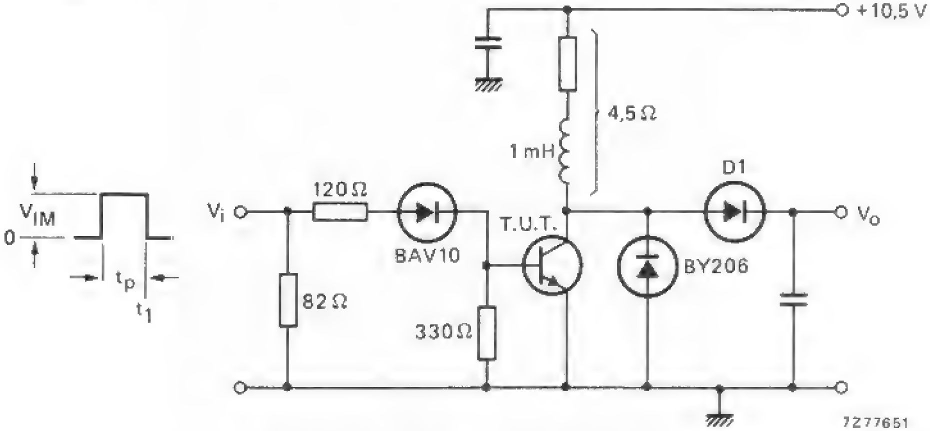


Fig. 10 Test circuit: $V_{IM} = 50$ V; $t_p = 3$ ms; $\delta \leq 0{,}03$.
D1 = BY206 or combinations of suitable faster diodes.
V_o Adjusted to make $V_{(CL)}$ equal to rated V_{CEOmax} (see Fig. 11).

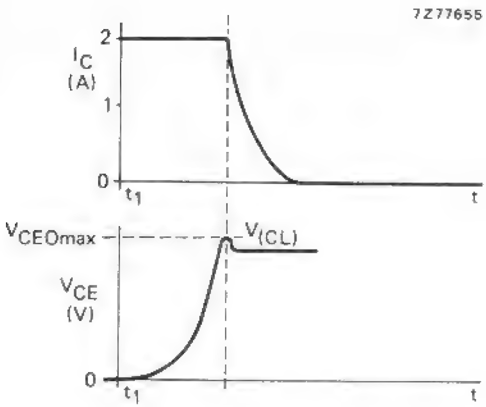


Fig. 11 Waveforms.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes, primarily intended for high-speed saturated switching and h.f. amplifier applications.

QUICK REFERENCE DATA

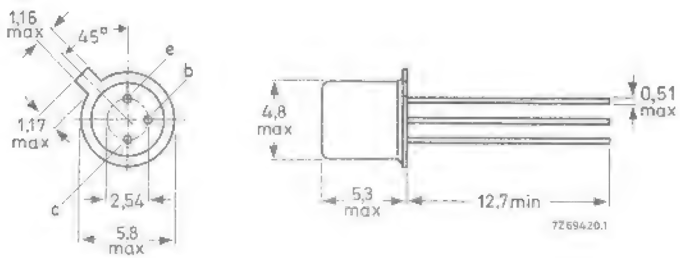
			BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	40	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	360	mW
D.C. current gain at T_j = 25 °C					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		20 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	10	20	
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V	f_T	>	400	500	MHz
Storage time					
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	<	10	13	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with $V_{BE} = 0$	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; $t \leq 10\ \mu s$)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		-65 to +200	^{o}C
Junction temperature	T_j	max.	200	^{o}C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.48	$^{o}C/mW$
From junction to case	$R_{th\ j-c}$	=	0.15	$^{o}C/mW$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

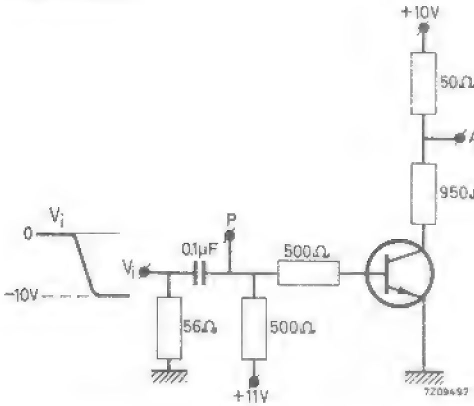
CHARACTERISTICS $T_j = 25\ ^{\circ}C$ unless otherwise specified

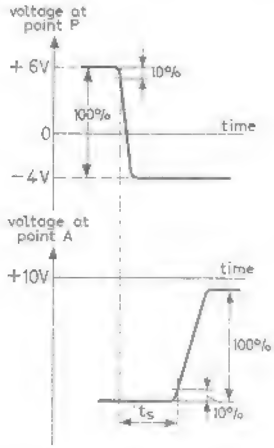
Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150\ ^{\circ}C$	I_{CBO}	<	30	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 55\ ^{\circ}C$	I_{CES}	<	0.40	μA
$V_{BE} = 0$; $V_{CE} = 40$ V	I_{CES}	<	1.0	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4.5$ V	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55\ ^{\circ}C$	I_{CEX}	<	0.60	μA
	$-I_{BEX}$	<	0.60	μA
Sustaining voltages				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 10$ mA; $R_{BE} = 10\ \Omega$	$V_{CERsust}$	>	20	V
Base-emitter voltage (see also page 8)				
$I_C = 30\ \mu$A; $V_{CE} = 20$ V; $T_j = 100\ ^{\circ}C$	V_{BE}	>	0.35	V
Saturation voltages				
$I_C = 10$ mA; BSX19: $I_B = 0.6$ mA; BSX20: $I_B = 0.3$ mA	V_{CEsat}	<	0.3	V
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	0.70 to	0.85	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.60	V
	V_{BEsat}	<	1.50	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4.5	pF

CHARACTERISTICS (continued) $T_j = 25\ ^{\circ}C$ unless otherwise specified

		BSX19	BSX20	
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	20 to 60	40 to 120	
$I_C = 10$ mA; $V_{CE} = 1$ V; $T_j = -55\ ^{\circ}C$	h_{FE}	> 10	20	
$I_C = 100$ mA; $V_{CE} = 2$ V	h_{FE}	> 10	20	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	> 400	500	MHz
		typ. 500	600	MHz
Switching times				
Storage time (see also relevant Figs.)				
$I_C = I_B = -I_{BM} = 10$ mA	t_s	typ. 5	6	ns
		< 10	13	ns

Test circuit:





Pulse generator:				
Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

Oscilloscope:				
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

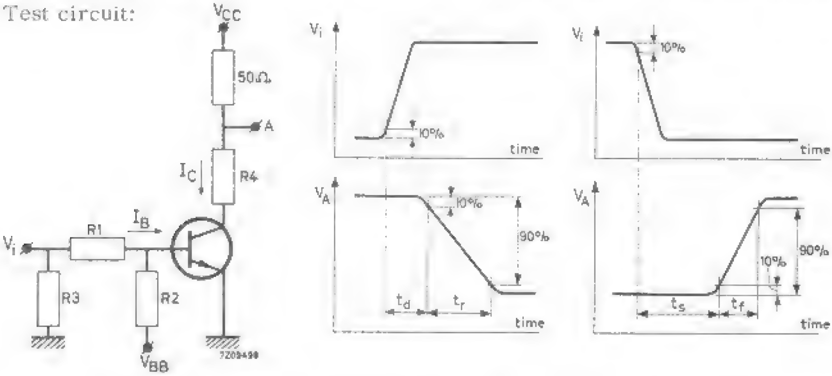
Turn on time (see also relevant Figs.)

from $-V_{BE}$ = 1.5 V to I_C = 10 mA; I_B = 3 mA		t_{on}	<	12	ns
from $-V_{BE}$ = 2.25 V to I_C = 100 mA; I_B = 40 mA		t_{on}	<	7	ns

Turn off time (see also relevant Figs.) 19)

from I_C = 10 mA; I_B = 3 mA	BSX19	t_{off}	<	15	ns
to cut-off with $-I_{BM}$ = 1.5 mA	BSX20	t_{off}	<	18	ns
from I_C = 100 mA; I_B = 40 mA to cut-off	BSX19	t_{off}	<	18	ns
with $-I_{BM}$ = 20 mA	BSX20	t_{off}	<	21	ns

Test circuit:



Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

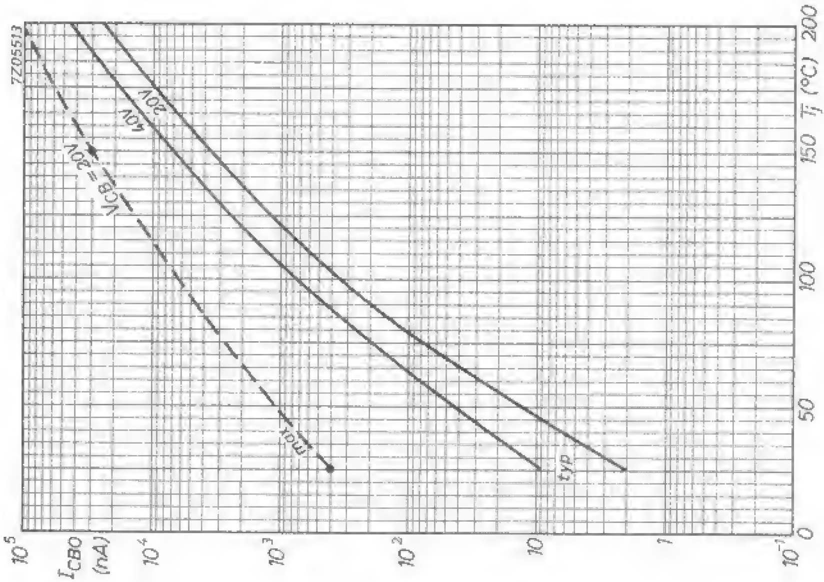
Oscilloscope:

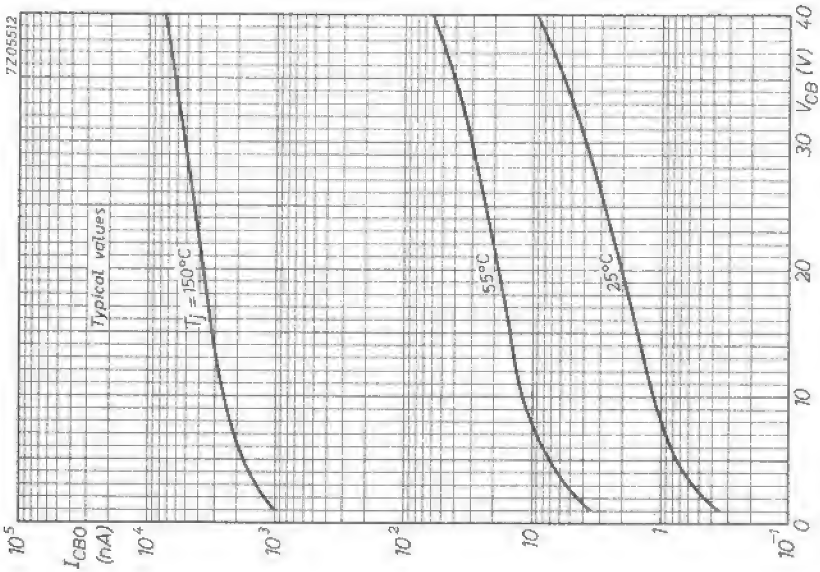
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

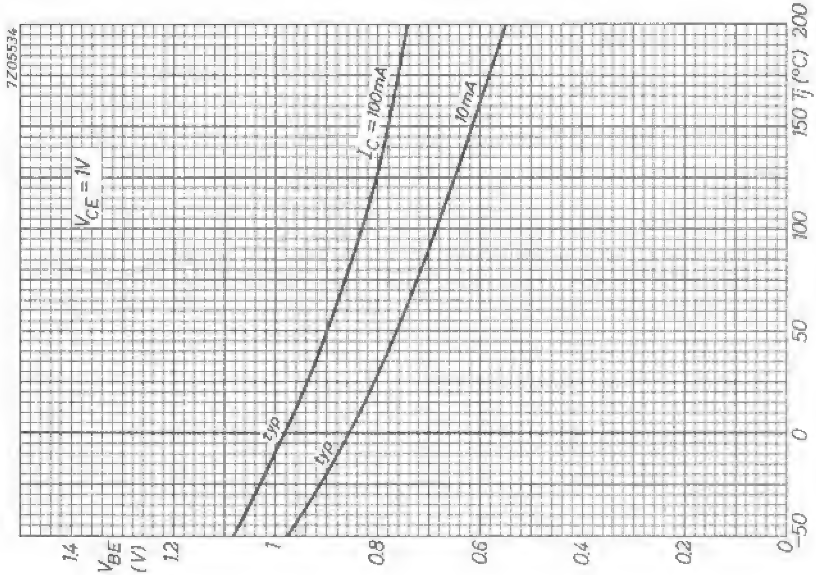
							turn on time			turn off time	
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1;R2 (kΩ)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	$-V_{BE}$ (V)	V_i (V)	V_{BB} (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

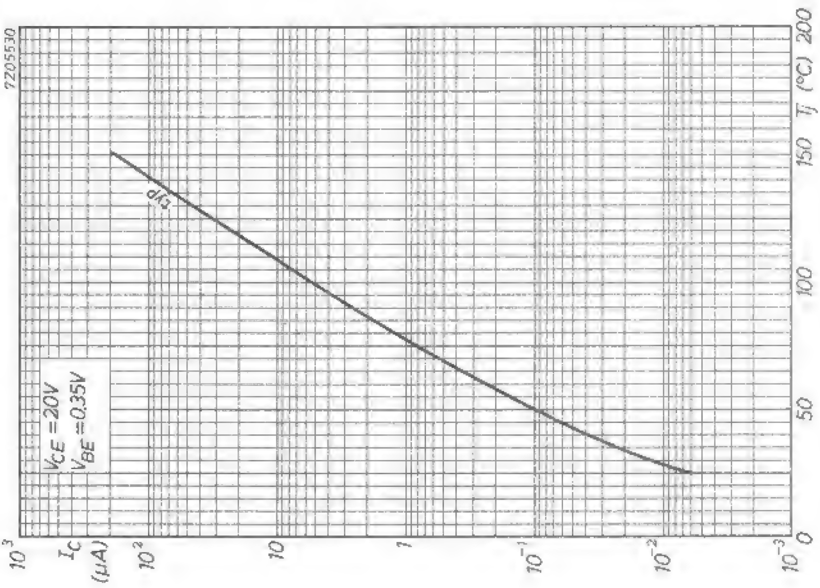
Note

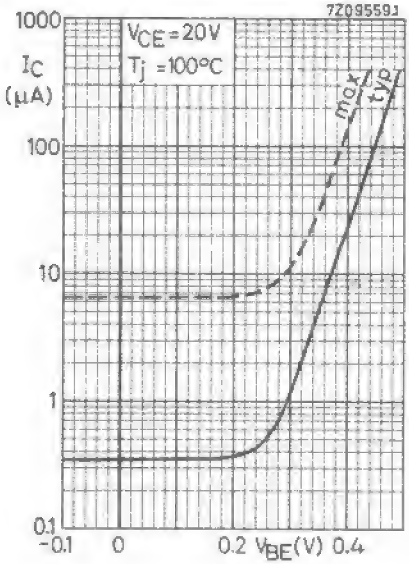
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

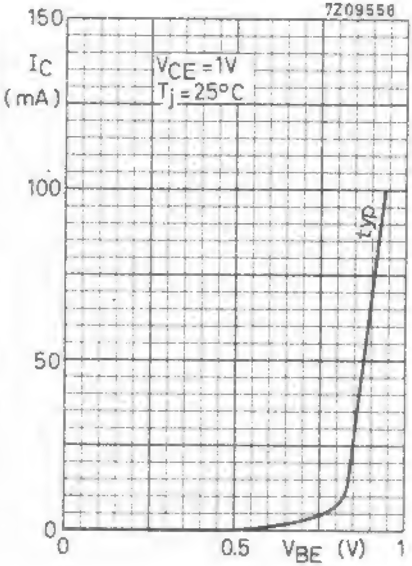

7Z05513
I_{CBO} (nA)
T_j (°C)
V_{CB} = 20V
40V
20V
max
typ

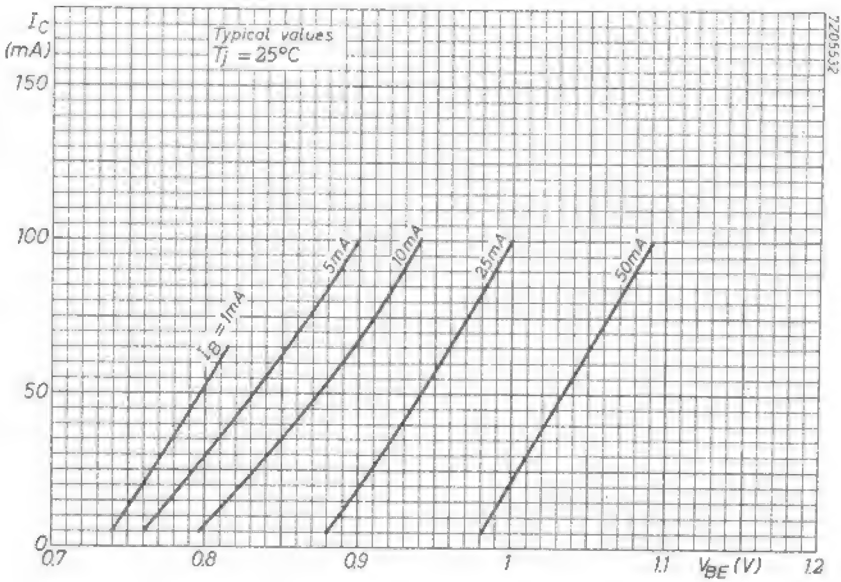

7Z05512
Typical values
I_{CBO} (nA)
V_{CB} (V)
T_j = 150°C
55°C
25°C

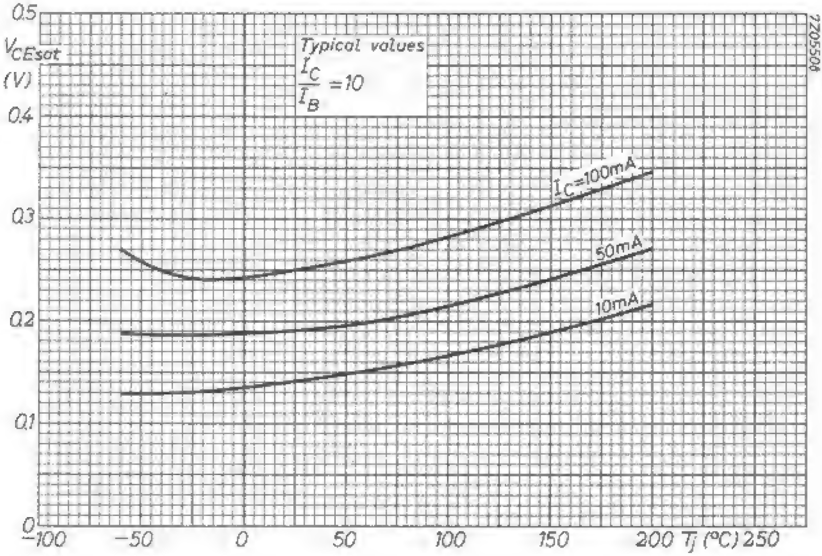

7Z05534
$V_{CE} = 1V$
$I_C = 100mA$
10mA
typ
typ
V_{BE} (V)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−50
0
50
100
150
200
T_j (°C)

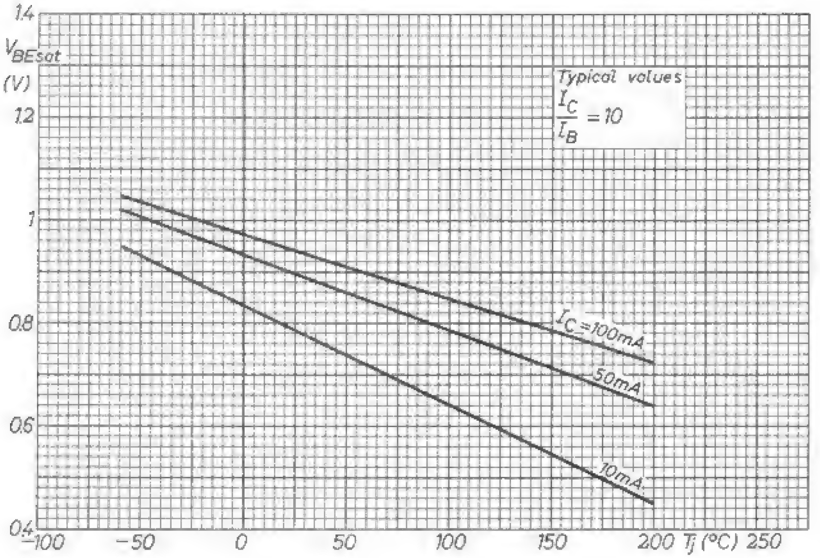

7Z05530
$V_{CE} = 20V$
$V_{BE} = 0.35V$
typ
I_C (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)

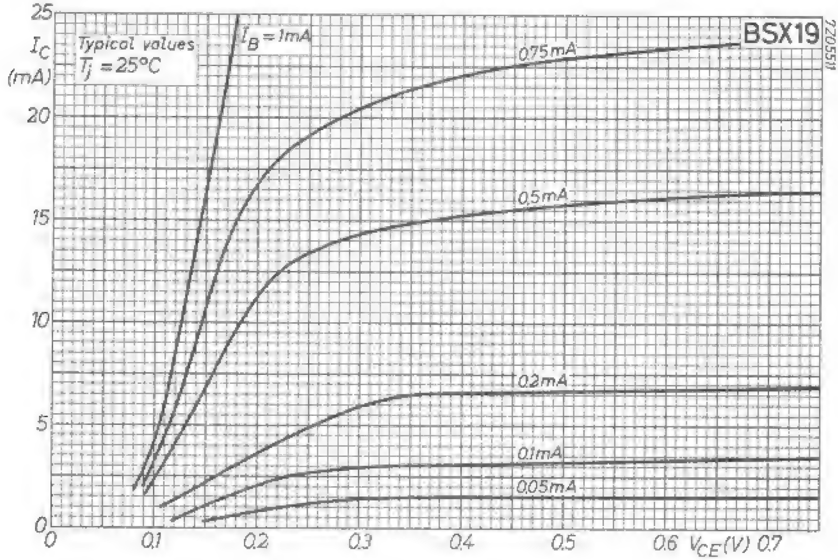

7Z09559.1
1000
I_C
(μA)
100
10
1
0.1
V_{CE} = 20 V
T_j = 100 °C
max
typ
−0.1
0
0.2
V_{BE} (V)
0.4

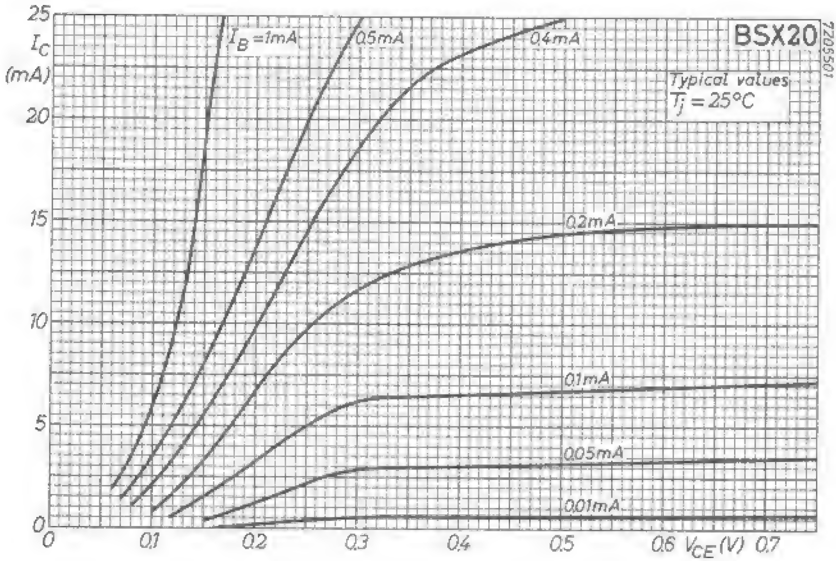

7Z09556
150
I_C
(mA)
100
50
0
V_{CE} = 1 V
T_j = 25 °C
typ
0
0.5
V_{BE} (V)
1

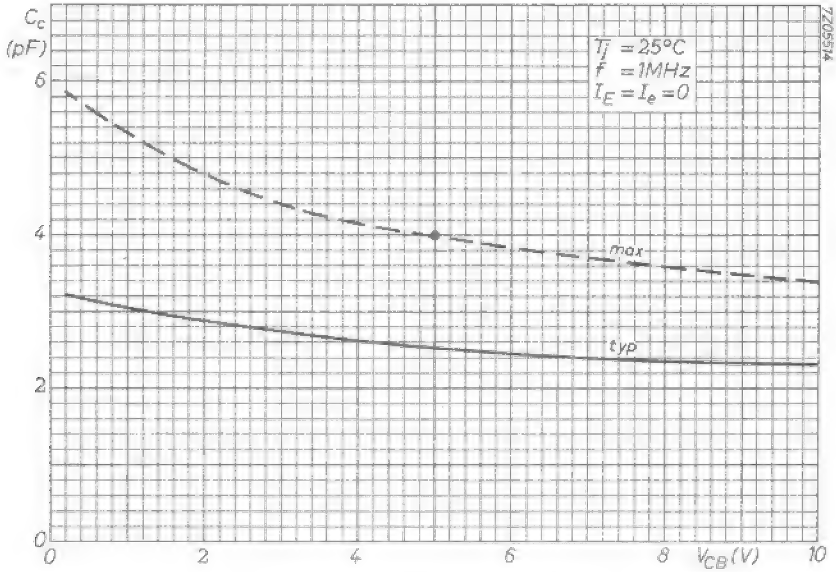

7Z05532
I_C
(mA)
150
100
50
0
Typical values
T_j = 25 °C
I_B = 1 mA
5 mA
10 mA
25 mA
50 mA
0.7
0.8
0.9
1
1.1
V_{BE} (V)
1.2

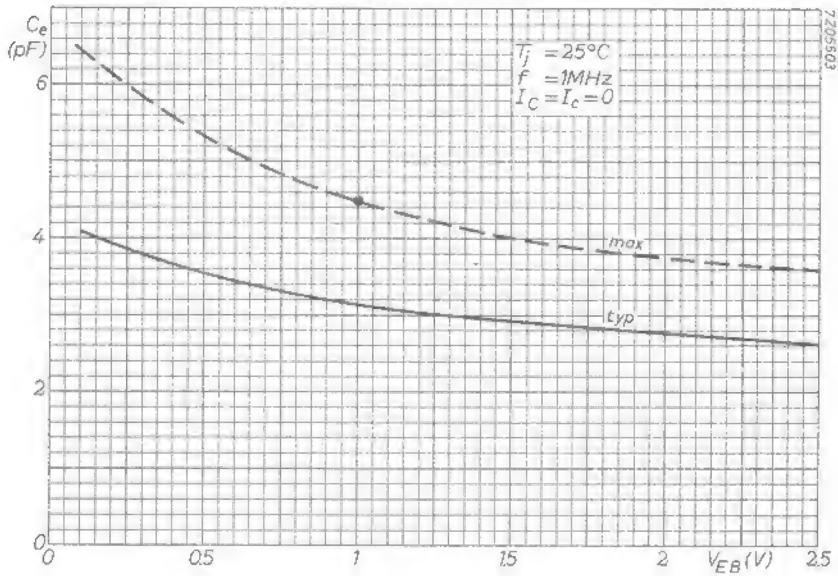

0.5
V_{CEsat}
(V)
0.4
0.3
0.2
0.1
0
Typical values
$\frac{I_C}{I_B} = 10$
7Z05506
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200 T_j (°C) 250

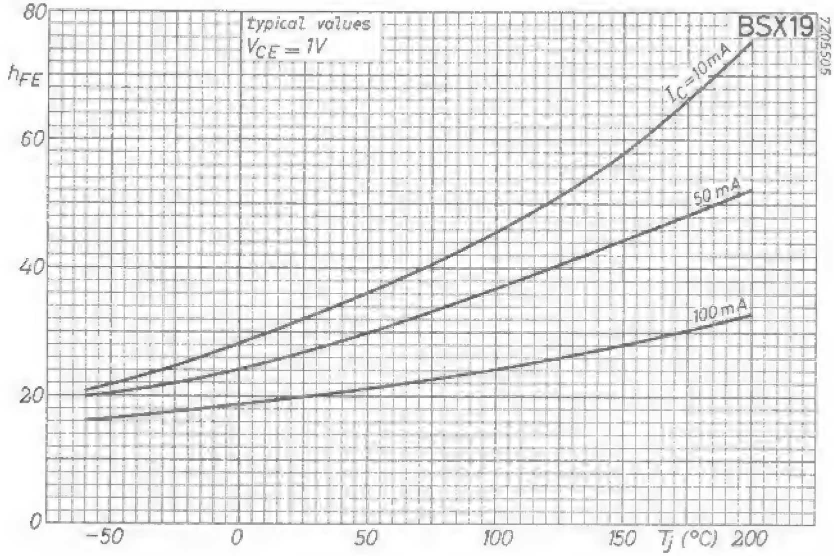

1.4
V_{BEsat}
(V)
1.2
1
0.8
0.6
0.4
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200 T_j (°C) 250

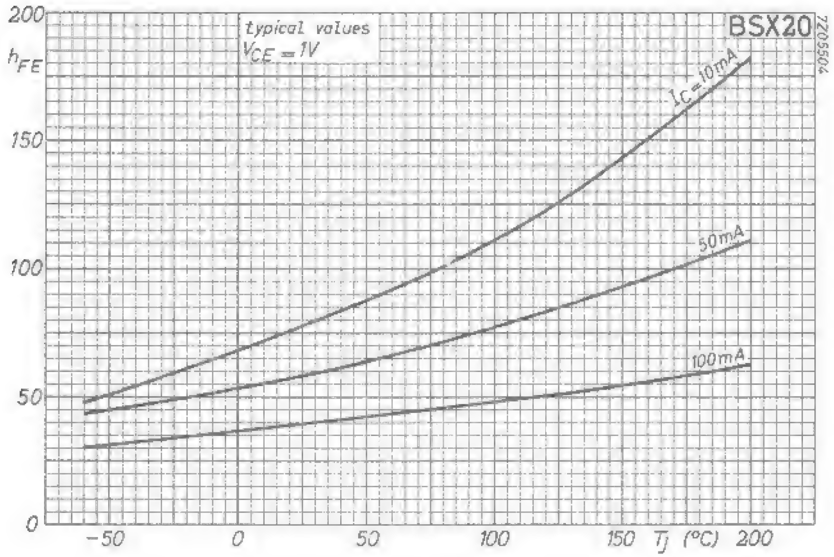

BSX19
7205511
Typical values
$T_j = 25°C$
I_C (mA)
$I_B = 1mA$
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
V_{CE} (V)
0
5
10
15
20
25
0.1
0.2
0.3
0.4
0.5
0.6
0.7

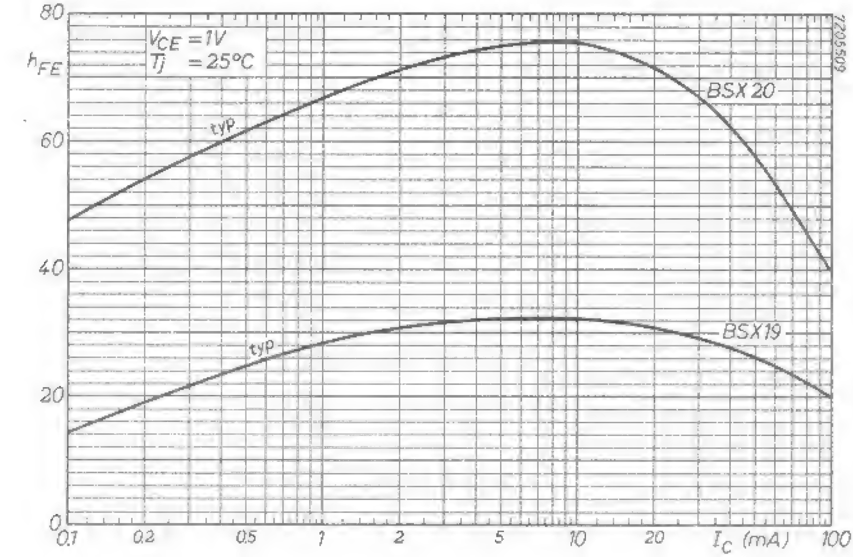

BSX20
7205501
Typical values
$T_j = 25°C$
I_C (mA)
$I_B = 1mA$
0.5mA
0.4mA
0.2mA
0.1mA
0.05mA
0.01mA
V_{CE} (V)
0
5
10
15
20
25
0.1
0.2
0.3
0.4
0.5
0.6
0.7

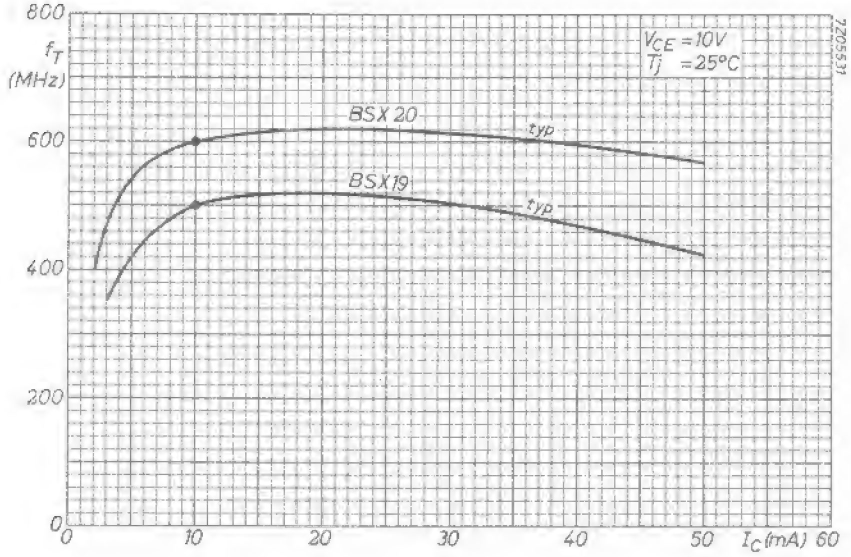

C_c
(pF)
7205514
$T_j = 25°C$
$f = 1MHz$
$I_E = I_e = 0$
max
typ
V_{CB} (V)
0
2
4
6
8
10

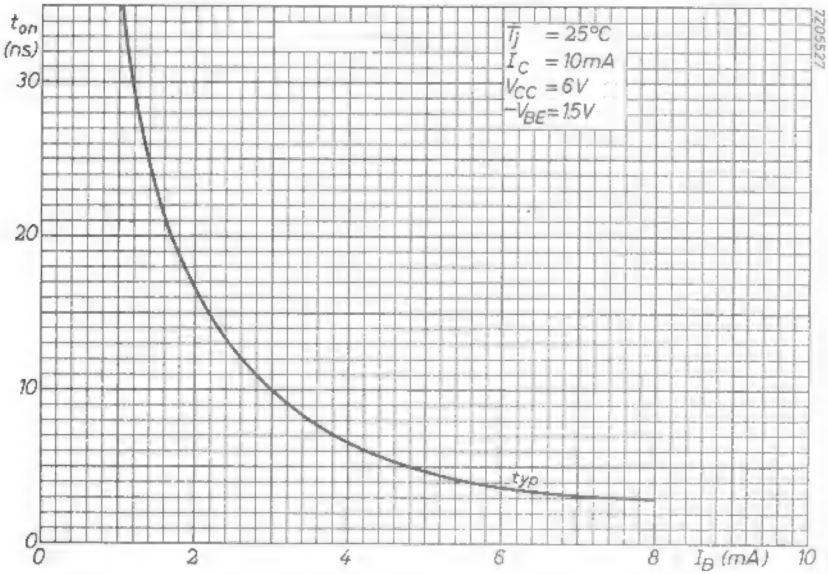

C_e
(pF)
7205503
$T_j = 25°C$
$f = 1MHz$
$I_C = I_c = 0$
max
typ
V_{EB} (V)
0
0.5
1
1.5
2
2.5

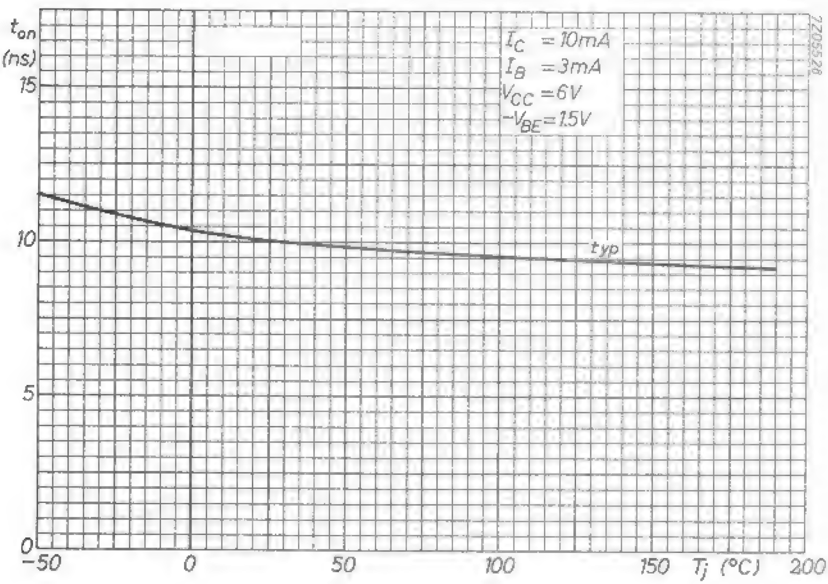

80
60
40
20
0
h_{FE}
typical values
$V_{CE} = 1V$
BSX19
7Z05505
$I_C = 10mA$
50 mA
100 mA
−50
0
50
100
150
T_j (°C)
200

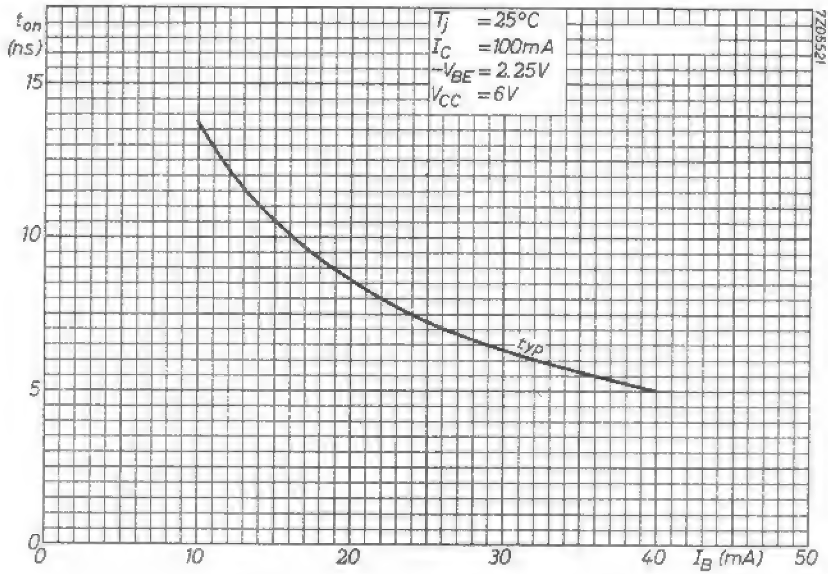

200
150
100
50
0
h_{FE}
typical values
$V_{CE} = 1V$
BSX20
7Z05504
$I_C = 10mA$
50 mA
100 mA
−50
0
50
100
150
T_j (°C)
200

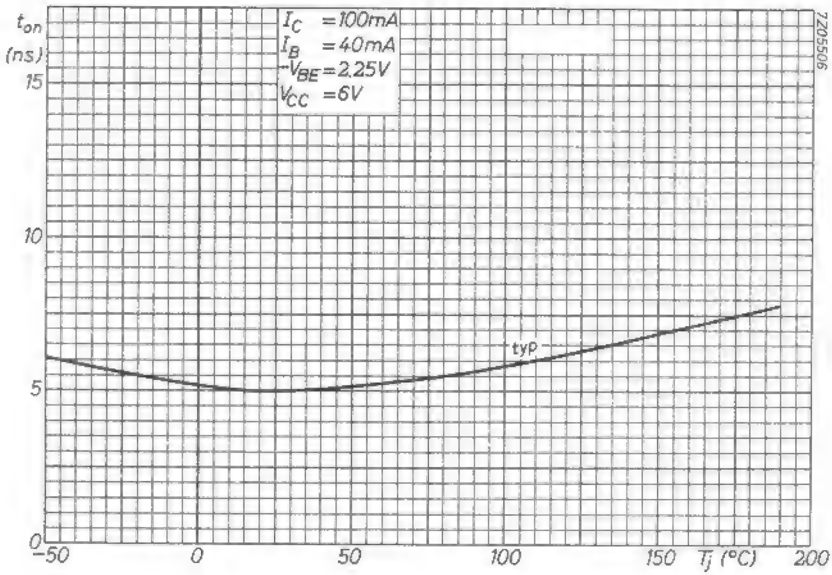

7205509
V_{CE} = 1V
T_j = 25°C
h_{FE}
80
60
40
20
0
typ
typ
BSX 20
BSX19
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

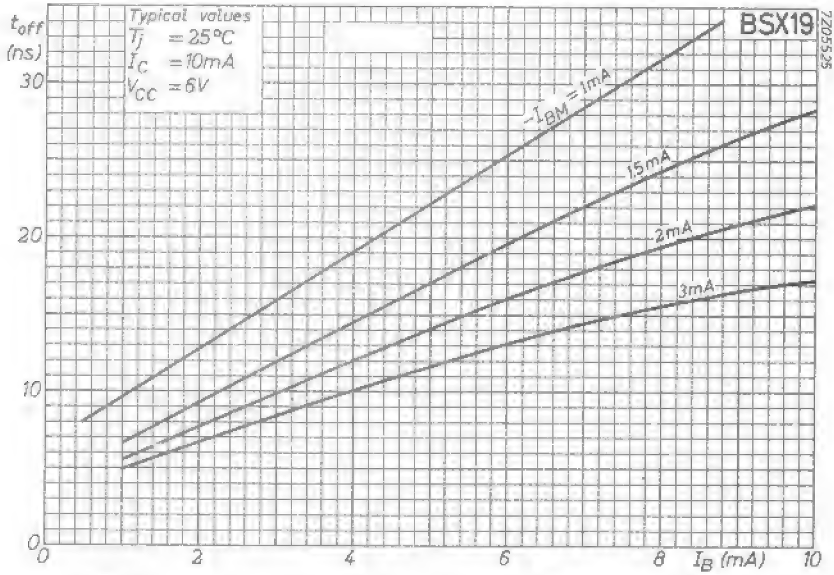

7205531
V_{CE} = 10V
T_j = 25°C
f_T
(MHz)
800
600
400
200
0
BSX 20
BSX19
typ
typ
0
10
20
30
40
50
I_C(mA) 60

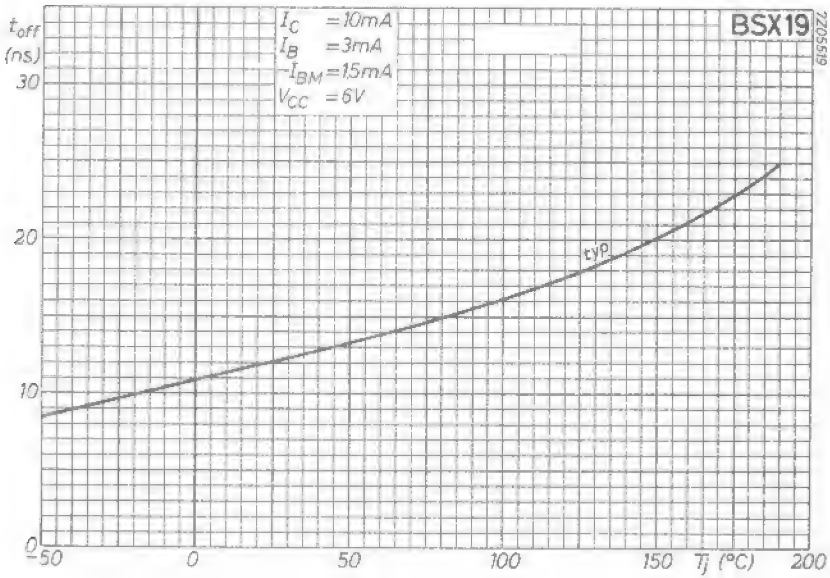

t_{on} (ns)
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
I_B (mA)
7205527

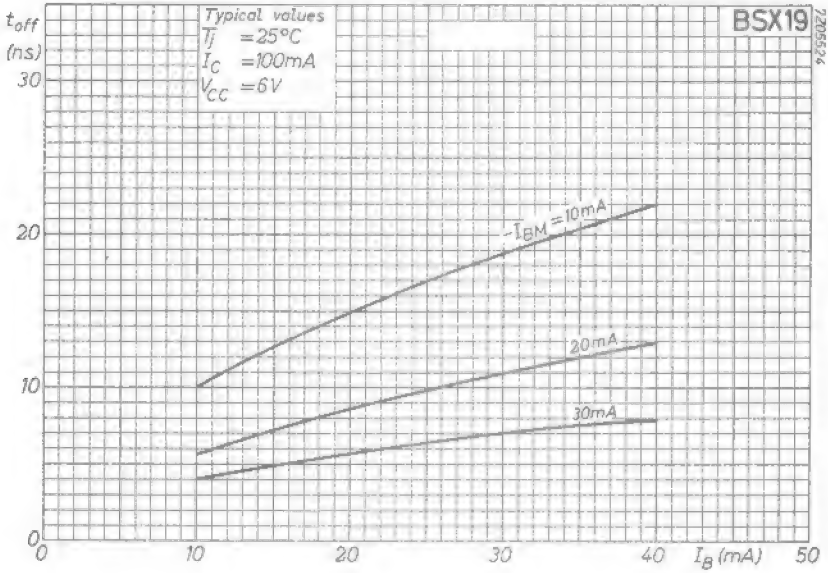

t_{on} (ns)
I_C = 10mA
I_B = 3mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
T_j (°C)
7205526

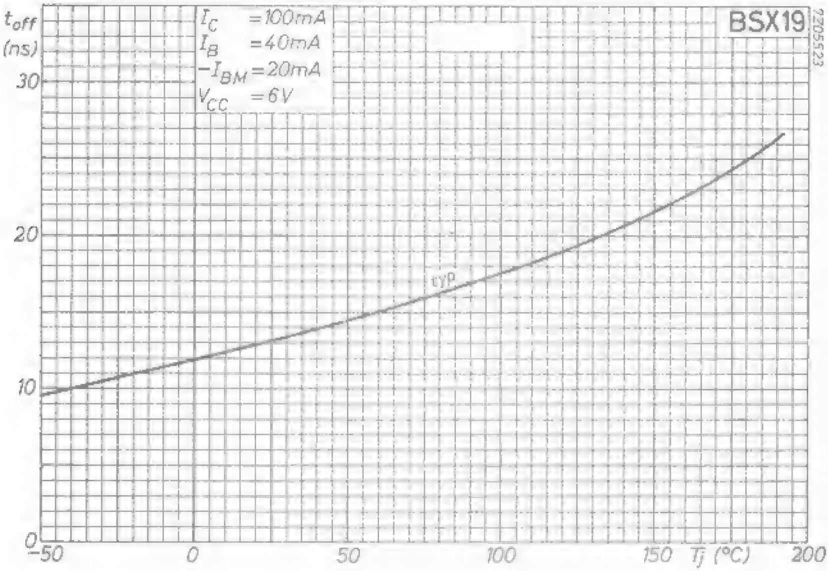

t_{on} (ns)
T_j = 25°C
I_C = 100mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
7Z05521
typ
0
5
10
15
0
10
20
30
40
I_B (mA)
50

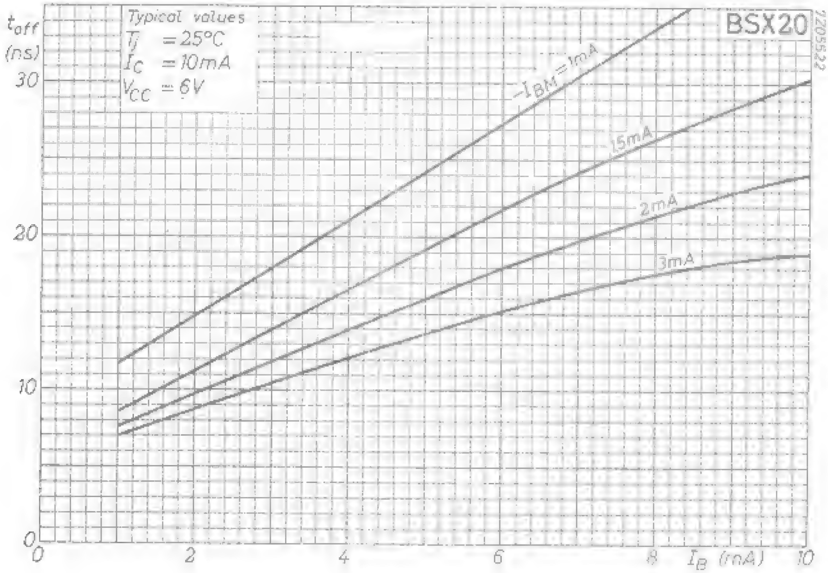

t_{on} (ns)
I_C = 100mA
I_B = 40mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
7Z05506
typ
0
5
10
15
−50
0
50
100
150
T_j (°C)
200

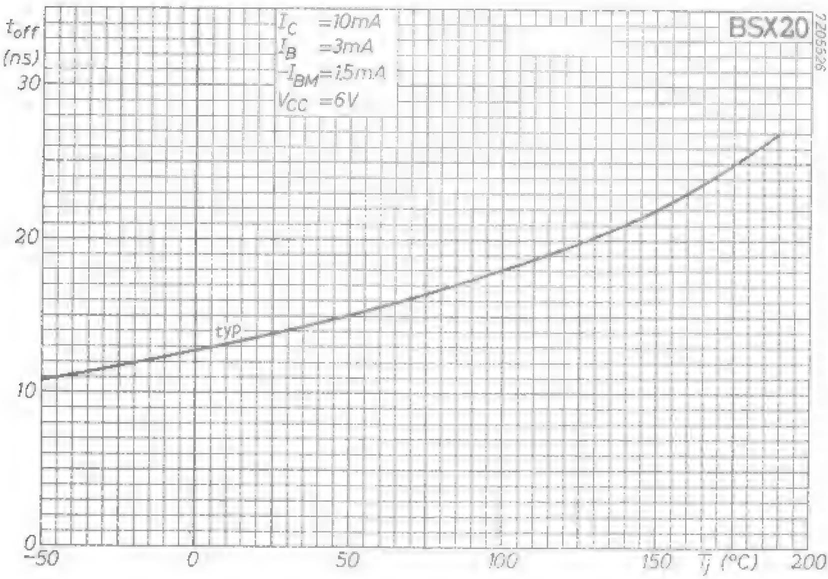

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
BSX19
7Z05525
t_{off} (ns)
$-I_{BM}$ = 1mA
1.5mA
2mA
3mA
30
20
10
0
0
2
4
6
8
I_B (mA)
10

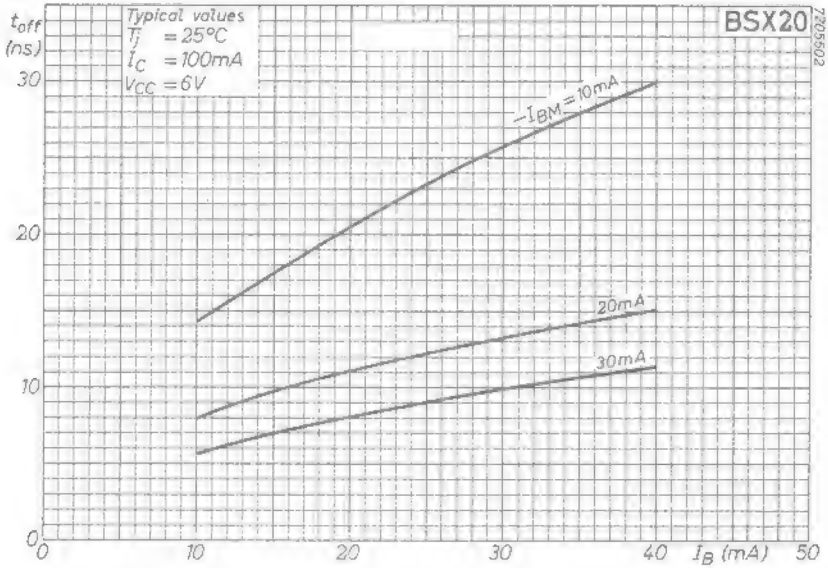

I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
BSX19
7Z05519
t_{off} (ns)
typ
30
20
10
0
-50
0
50
100
150
T_j (°C)
200

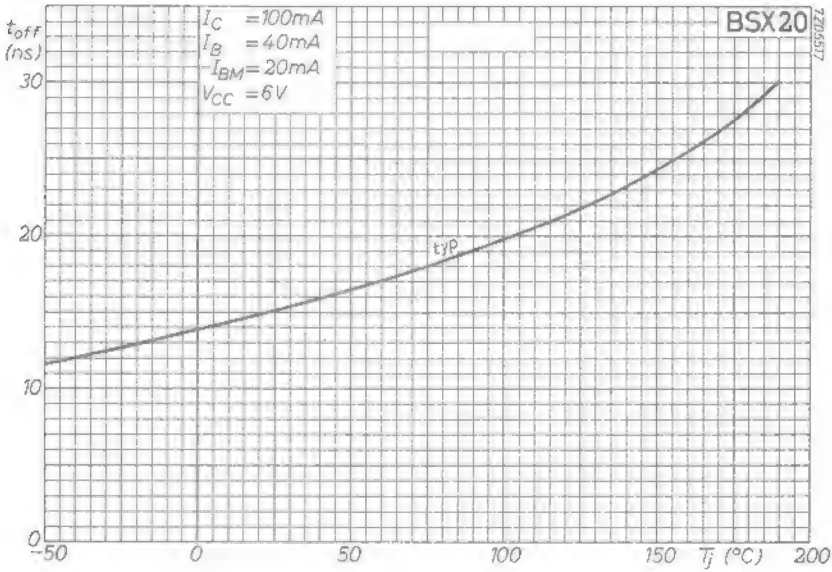

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
BSX19
7205526
$-I_{BM}$ = 10mA
20mA
30mA
I_B (mA)
0
10
20
30
0
10
20
30
40
50

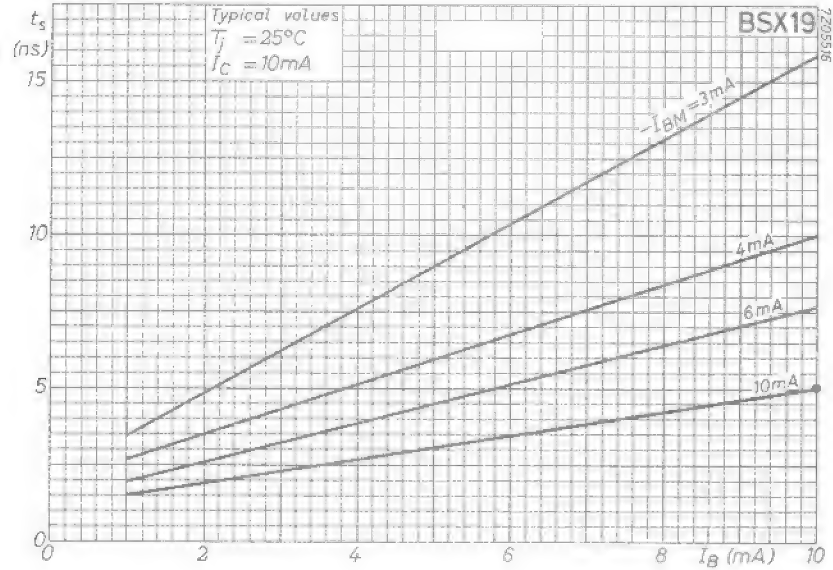

t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
BSX19
7205523
typ
T_j (°C)
0
10
20
30
−50
0
50
100
150
200

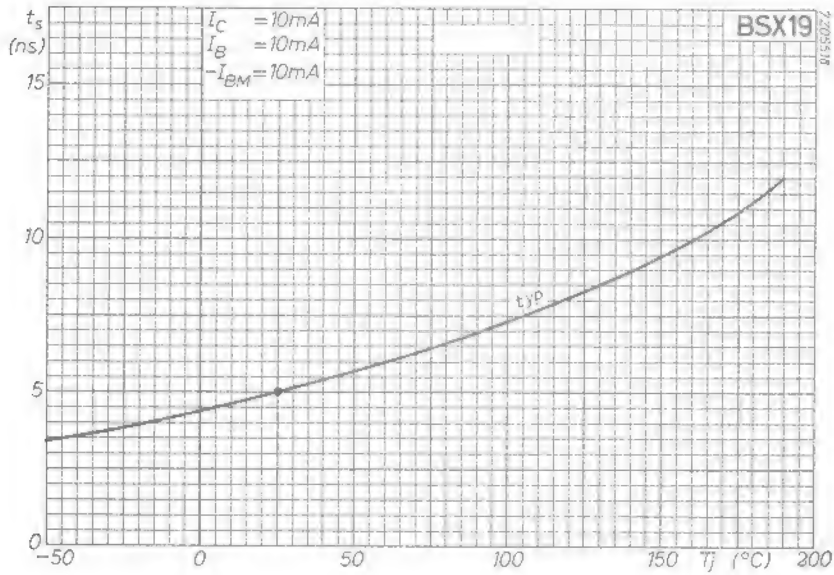

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
BSX20
7205522
t_{off} (ns)
$-I_{BM}$=1mA
1.5mA
2mA
3mA
I_B (mA)
0
2
4
6
8
10
20
30

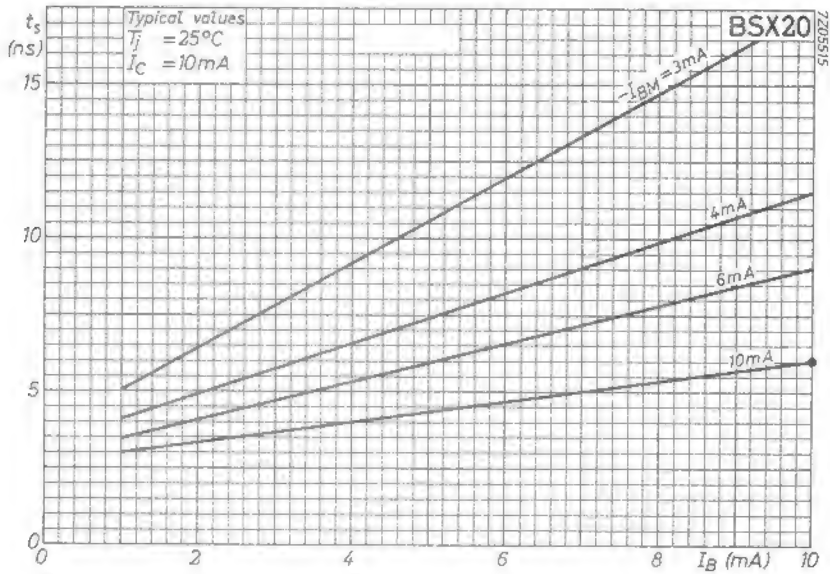

I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
BSX20
7205526
t_{off} (ns)
typ
T_j (°C)
-50
0
50
100
150
200
10
20
30

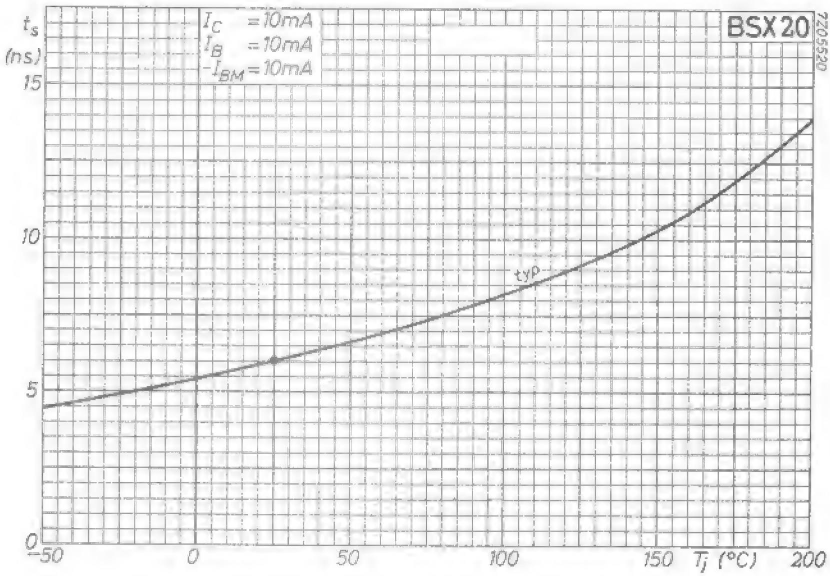

Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
BSX20
7Z05502
t_{off} (ns)
$-I_{BM}$ = 10mA
20mA
30mA
30
20
10
0
0
10
20
30
40
I_B (mA)
50


I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
BSX20
7Z05517
t_{off} (ns)
typ
30
20
10
0
-50
0
50
100
150
T_j (°C)
200


t_s (ns)
Typical values
Tj = 25°C
IC = 10mA
BSX19
7Z05516
-IBM = 3mA
4mA
6mA
10mA
0
5
10
15
0
2
4
6
8
IB (mA)
10


t_s (ns)
IC = 10mA
IB = 10mA
-IBM = 10mA
BSX19
7Z05518
typ
0
5
10
15
-50
0
50
100
150
Tj (°C)
200


BSX20
7Z05515
Typical values
T_j =25°C
I_C =10mA
t_s (ns)
$-I_{BM}$=3mA
4mA
6mA
10mA
I_B (mA)
0
2
4
6
8
10
5
15


BSX20
7Z05520
I_C =10mA
I_B =10mA
$-I_{BM}$=10mA
t_s (ns)
typ
T_j (°C)
−50
0
50
100
150
200
5
10
15

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes with the collector connected to the case. These transistors are intended for general industrial applications.

QUICK REFERENCE DATA

			BSX45	BSX46	BSX47	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	V
Collector current (d.c.)	I_C	max.		1		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		6,25		W
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>		50		MHz

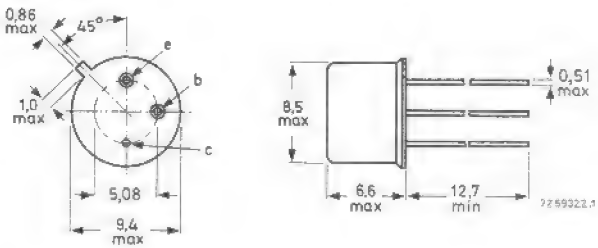
			BSX45–6 BSX46–6 BSX47–6	BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	> <	40 100	63 160	100 250

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.
Accessories: 56245 (distance disc).

Products approved to CECC 50 002-174, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BSX45	BSX46	BSX47	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	V
Collector current (d.c.)	I_C	max.		1		A
Base current (d.c.)	I_B	max.		200		mA
Total power dissipation up to $T_{case} = 25\ ^oC$	P_{tot}	max.		6,25		W
Storage temperature	T_{stg}			−65 to + 200		^oC
Junction temperature	T_j	max.		200		^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	28	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified			BSX45	BSX46	BSX47	
Collector cut-off currents						
V_{BE} = 0; V_{CE} = 60 V	I_{CES}	typ.	1	1	–	nA
		<	30	30	–	nA
V_{BE} = 0; V_{CE} = 60 V; T_{amb} = 150 °C	I_{CES}	typ.	1	1	–	μA
		<	10	10	–	μA
V_{BE} = 0; V_{CE} = 80 V	I_{CES}	<	–	–	30	nA
V_{BE} = 0; V_{CE} = 80 V; T_{amb} = 150 °C	I_{CES}	<	–	–	10	μA
V_{BE} = 0,2 V; V_{CE} = 60 V; T_{amb} = 100 °C	I_{CEX}	<	50	50	–	μA
V_{BE} = 0,2 V; V_{CE} = 80 V; T_{amb} = 100 °C	I_{CEX}	<	–	–	50	μA
Emitter cut-off current						
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	10	10	nA
Collector-emitter breakdown voltage						
open base; I_C = 50 mA	$V_{(BR)CEO}$	>	40	60	80	V
V_{BE} = 0; I_C = 100 μA	$V_{(BR)CES}$	>	80	100	120	V
Emitter-base breakdown voltage						
open collector; I_E = 100 μA	$V_{(BR)EBO}$	>	7	7	7	V
Base-emitter voltage						
I_C = 100 mA; V_{CE} = 1 V	V_{BE}	<	1	1	1	V
I_C = 500 mA; V_{CE} = 1 V	V_{BE}	>	0,75	0,75	0,75	V
		<	1,50	1,50	1,50	V
I_C = 1 A; V_{CE} = 1 V	V_{BE}	typ.	1,30	1,30	1,30	V
		<	2,00	2,00	2,00	V
Saturation voltage						
I_C = 1000 mA; I_B = 100 mA	V_{CEsat}	typ.	0,7	0,7	–	V
		<	1,0	1,0	–	V
I_C = 500 mA; I_B = 25 mA	V_{CEsat}	typ.	–	–	0,5	V
		<	–	–	0,9	V
Transition frequency at f = 20 MHz						
I_C = 50 mA; V_{CE} = 10 V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	25	20	15	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	80	80	80	pF
Noise figure at f = 1 kHz						
I_C = 100 μA; V_{CE} = 10 V						
R_S = 1 kΩ; B = 200 Hz	F	typ.	3,5	3,5	3,5	dB

			BSX45–6 BSX46–6 BSX47–6	BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16	
D.C. current gain						
$I_C = 100\ \mu A$; $V_{CE} = 1\ V$	h_{FE}	>	10	15	25	
		typ.	28	40	90	
$I_C = 100\ mA$; $V_{CE} = 1\ V$	h_{FE}	>	40	63	100	
		typ.	63	100	160	
		<	100	160	250	
$I_C = 500\ mA$; $V_{CE} = 1\ V$	h_{FE}	>	15	25	35	
		typ.	25	40	60	
$I_C = 1\ A$; $V_{CE} = 1\ V$	h_{FE}	typ.	15	20	30	
Switching times (see Fig. 2)						
$I_{Con} = 100\ mA$; $I_{Bon} = -I_{Boff} = 5\ mA$						
Turn-on time	t_{on}	<		200		ns
Turn-off time	t_{off}	<		850		ns

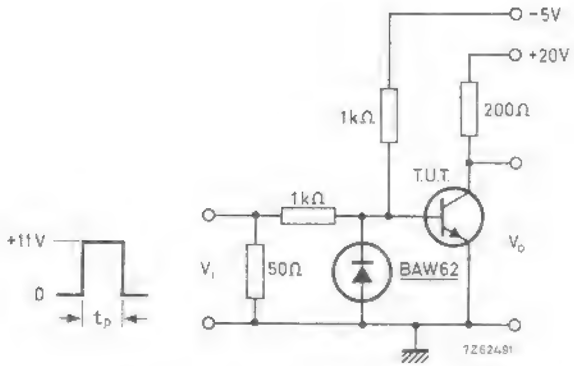


Fig. 2 Switching times test circuit.

Pulse generator:

Pulse duration	t_p	=	10 μs
Rise time	t_r	⩽	15 ns
Fall time	t_f	⩽	15 ns
Source impedance	Z_S	=	50 Ω

Oscilloscope:

Rise time	t_r	⩽	15 ns
Input impedance	Z_i	⩾	100 kΩ

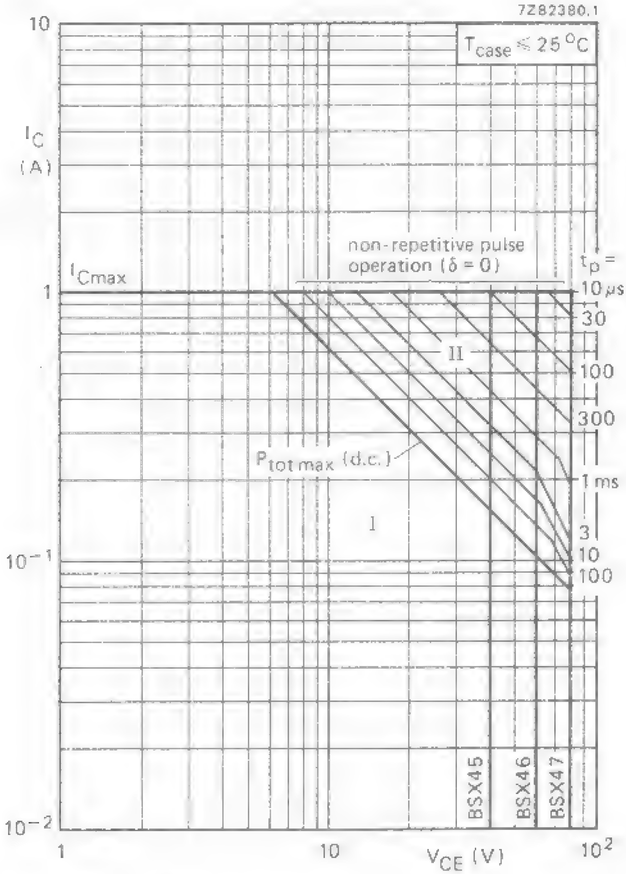


Fig. 3 Safe Operating ARea; $T_{case} \leqslant 25\ ^{o}C$*.

I Region of permissible d.c. operation.
II Permissible extension for non-repetitive pulse operation.

* At case temperatures $> 25\ ^{o}C$ derate constant power portion of boundaries such that:

$P_{(t_p, o)} = \frac{200 - T_{case}}{Z_{th\,(t_p,\,o)}}$. (For very short forward mode pulse durations, i.e. $t_p < 3\ \mu s$, assume 3 μs values for Z_{th}.)

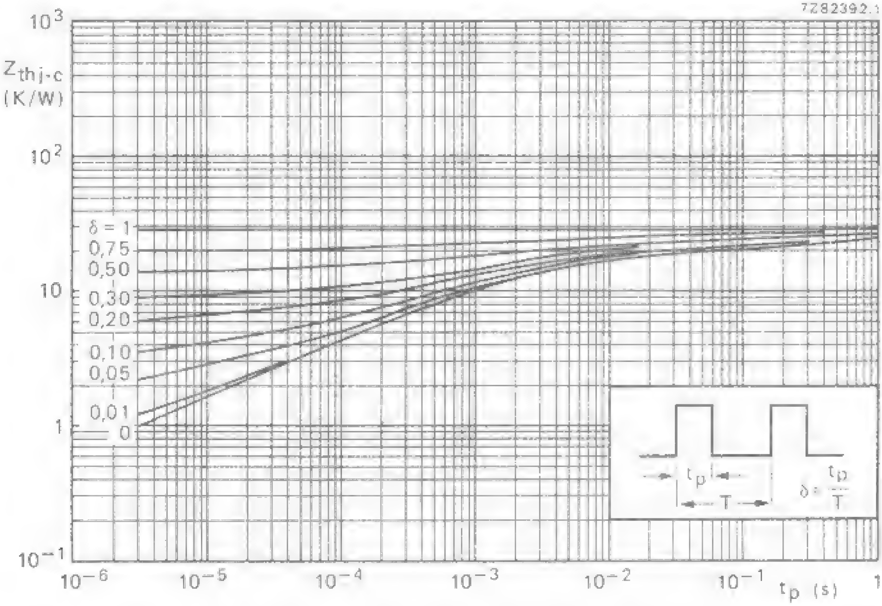


Fig. 4 Thermal impedance versus pulse duration. Stabilization time is 10 s.

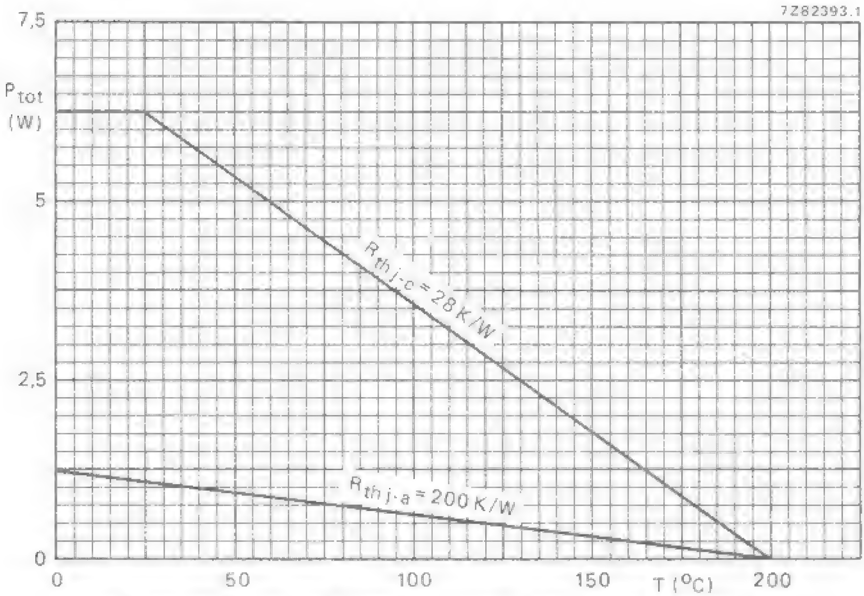


Fig. 5 Maximum permissible power dissipation as a function of temperature.

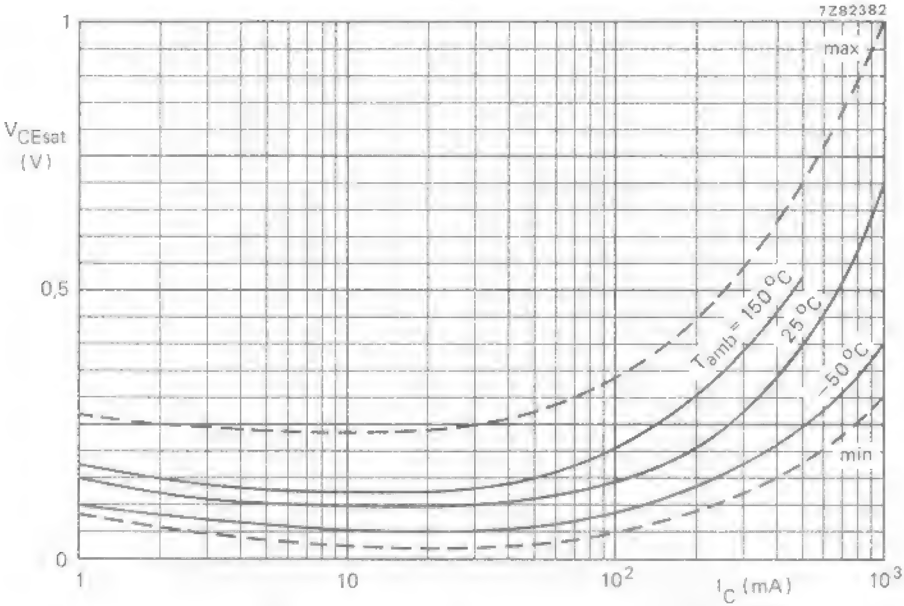


Fig. 6 I_C/I_B = 10; —— typical values; – – – limit values at T_{amb} = 25 °C.

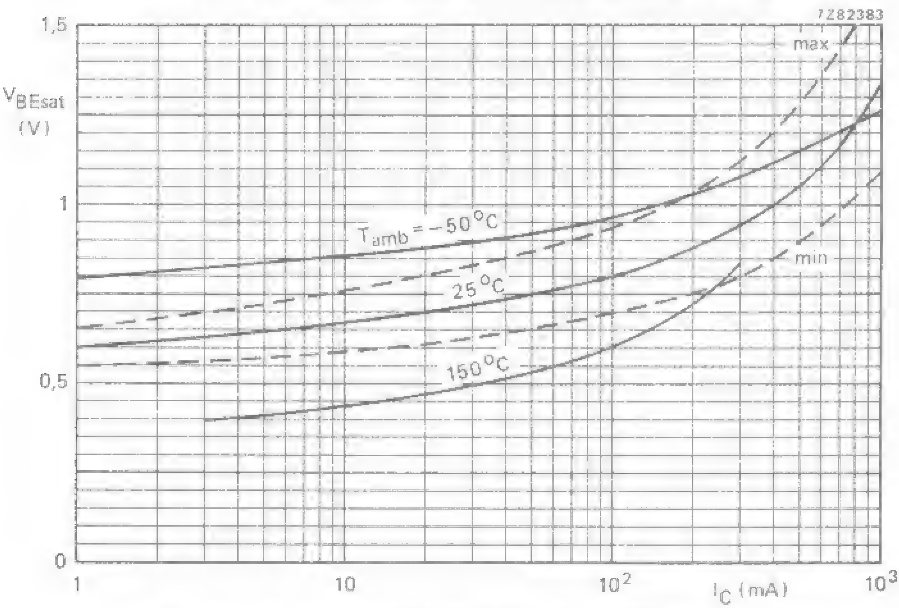


Fig. 7 I_C/I_B = 10; —— typical values; – – – limit values at T_{amb} = 25 °C.

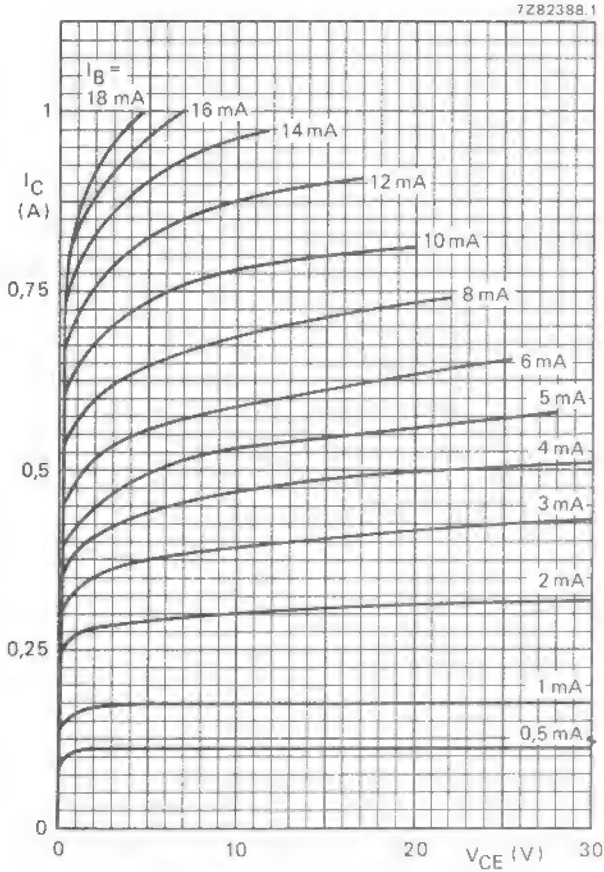


Fig. 8 Typical values; T_j = 25 °C.

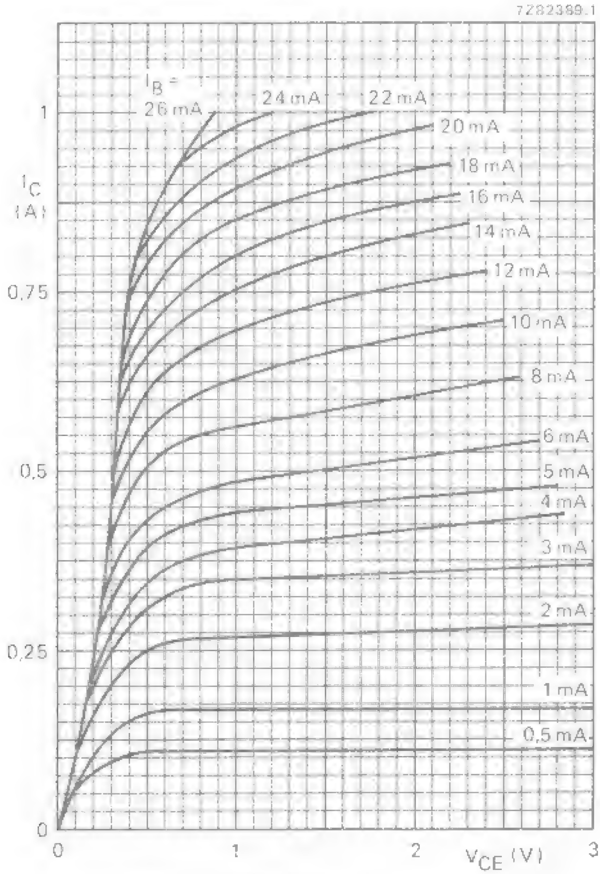


Fig. 9 Typical values; T_j = 25 °C.

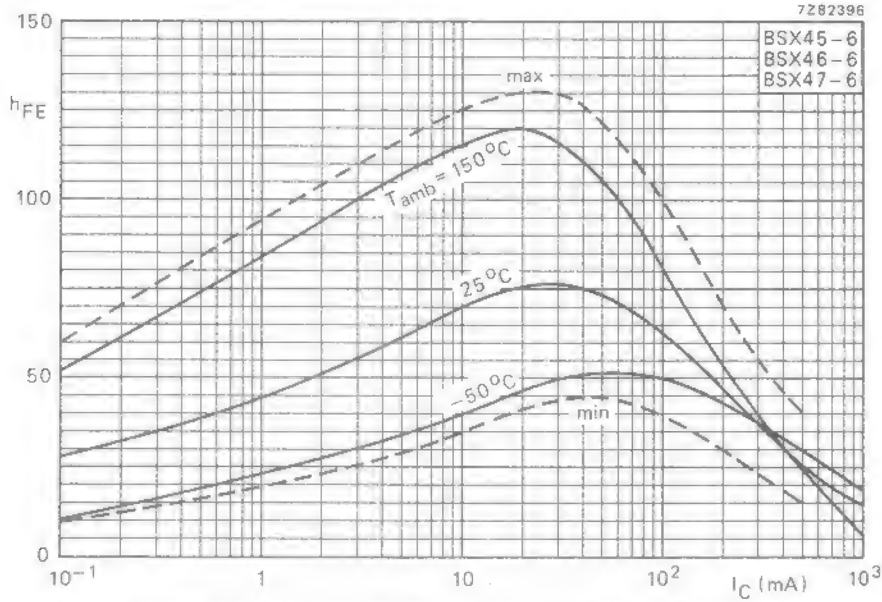


Fig. 10 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

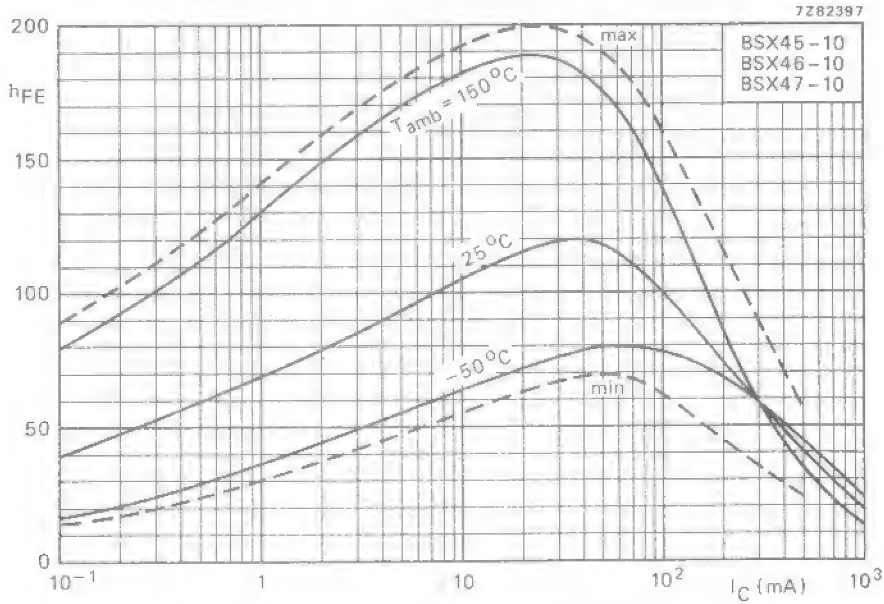


Fig. 11 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

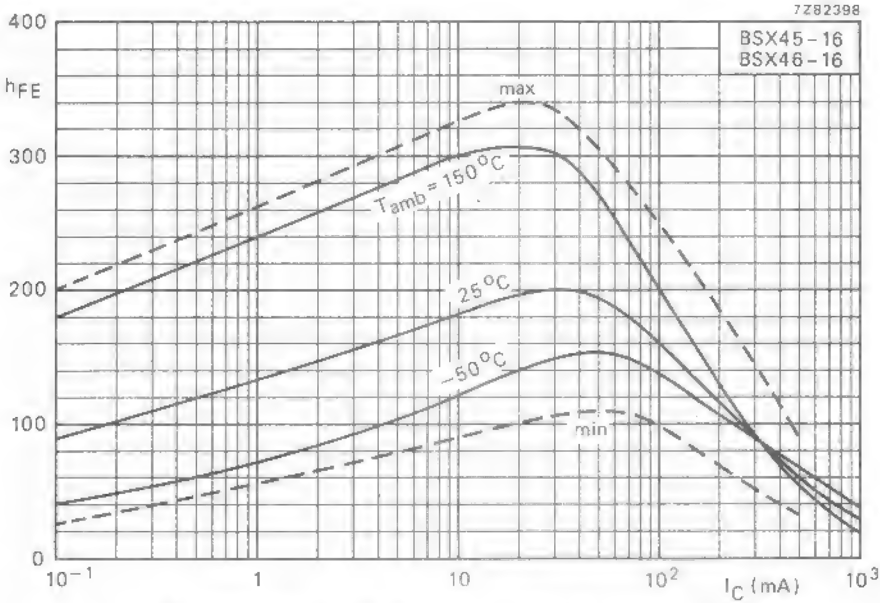


Fig. 12 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

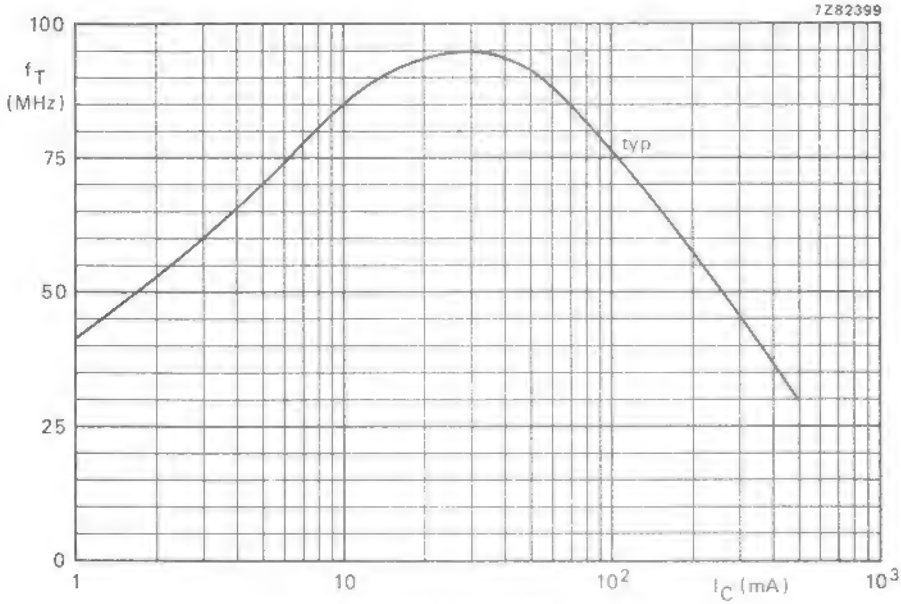


Fig. 13 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

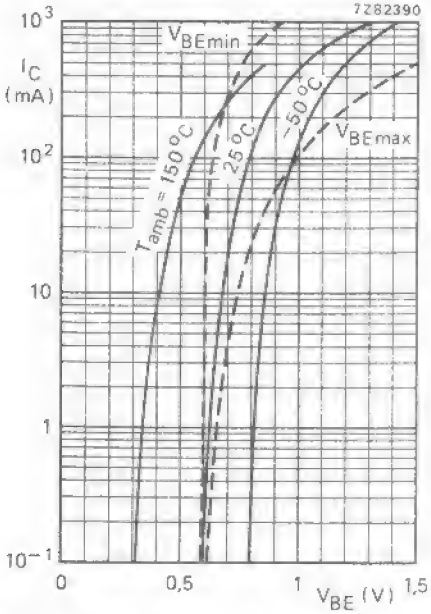


Fig. 14 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

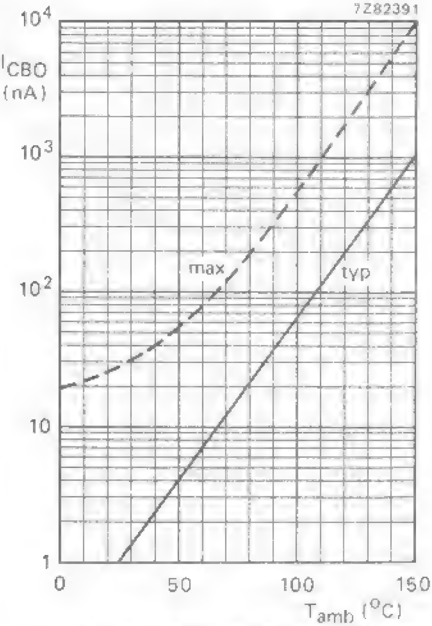


Fig. 15 V_{CBO} = 60 V for **BSX45** and **BSX46**; V_{CBO} = 80 V for **BSX47**.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The BSX59, BSX60 and BSX61 are primarily intended for very high speed core-driving purposes.

QUICK REFERENCE DATA

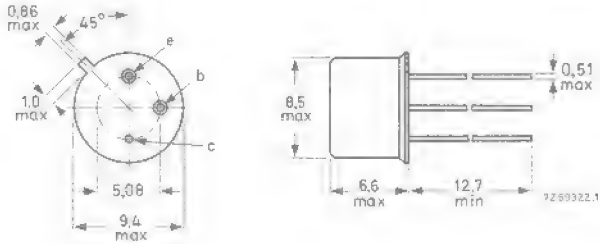
			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	30	30	30	
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5	0,5	0,7	V
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	450	475	475	MHz
Turn-off time I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 50 mA	t_{off}	<	60	70	100	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	45	30	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	1	A
Emitter current (peak value)	$-I_{EM}$	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\,j\text{-}c}$	=	43	°C/W
From junction to mounting base	$R_{th\,j\text{-}mb}$	=	35	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

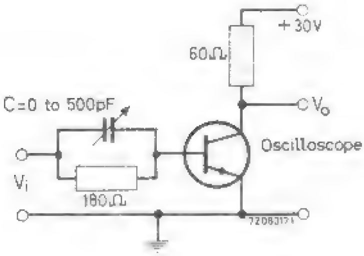
			BSX59	BSX60	BSX61	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	<	500	500	500	nA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	300	300	300	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	300	300	500	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	50	50	μA
Currents at reverse biased emitter junction						
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$+I_{CEX}$	<	500	500	1000	nA
	$-I_{BEX}$	<	500	500	1000	nA
$-V_{BE} = 4$ V; $V_{CE} = 40$ V; $T_j = 150$ °C	$+I_{CEX}$	<	300	300	500	μA
	$-I_{BEX}$	<	300	300	500	μA
Saturation voltages						
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.3	0.3	0.5	V
	V_{BEsat}	<	1.0	1.0	1.0	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5	0.5	0.7	V
	V_{BEsat}	>	0.85	0.7	0.7	V
		<	1.2	1.3	1.3	V
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	1.0	1.0	1.3	V
	V_{BEsat}	<	1.8	1.8	1.8	V
D.C. current gain						
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		typ.	70	90	105	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		<	90	90	90	
$I_C = 1$ A; $V_{CE} = 5$ V	h_{FE}	>	20	25	20	
		typ.	40	50	55	
Transition frequency						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	250	250	MHz
		typ.	450	475	475	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	6	6	6	pF
		<	10	10	10	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	36	36	36	pF
		<	50	50	50	pF

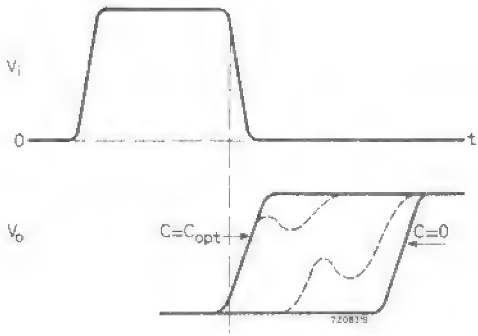
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Recovered charge

$I_C = 500$ mA; $I_B = 50$ mA BSX60 Q_s < 5 nC

Test circuit:





Adjust C from zero to C_{opt}
$Q_s = C_{opt} \cdot V_i$

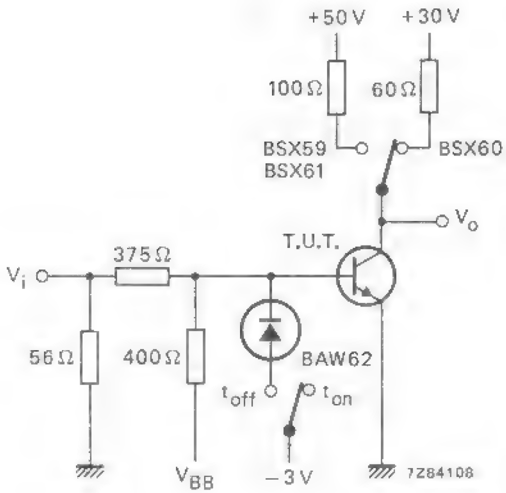
Pulse generator:

Pulse duration t_p = 10 μs

Duty cycle δ = 0.02

Switching times (see also Figs 4, 11 and 12)

			BSX59	BSX60	BSX61	
Turn-on time when switched from $-V_{BE}$ = 2 V to I_{Con} = 500 mA; I_{Bon} = 50 mA	t_{on}	typ.	17	17	18	ns
		<	35	40	50	ns
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 50 mA to cut-off with $-I_{Boff}$ = 50 mA*	t_{off}	typ.	45	58	70	ns
		<	60	70	100	ns



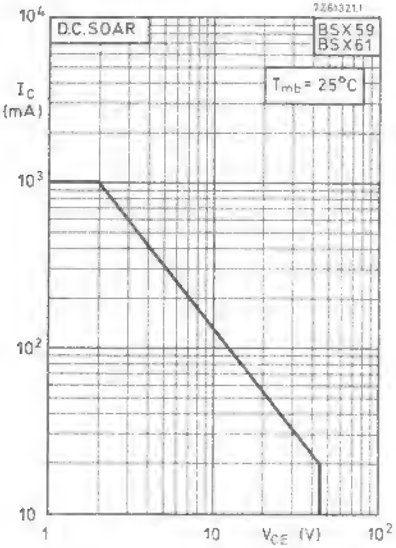
	t_{on}	t_{off}
$-V_{BB}$	4	16,7 V
V_i	24,75	37,5 V

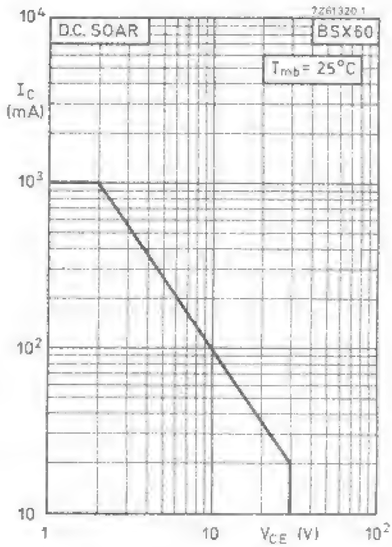
Fig. 4 Switching circuit.

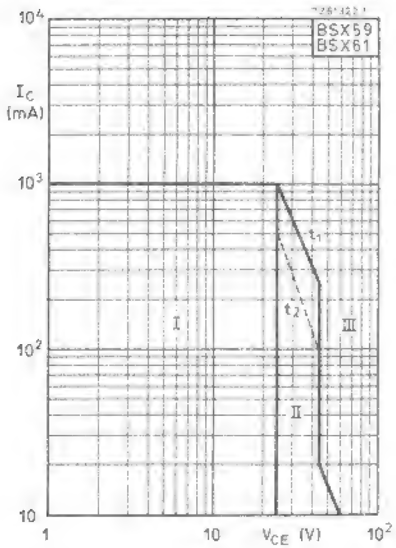
Pulse generator:

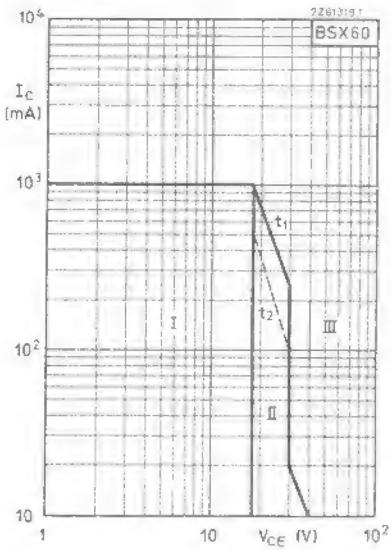
Pulse duration	t_p	≥	500 ns
Rise time	t_r	≤	5 ns
Fall time	t_f	≤	5 ns
Output resistance	R_o	=	50 Ω (during pulse, otherwise infinite)

* $-I_{Boff}$ is the reverse current that can flow during switching off. The indicated $-I_{Boff}$ is determined and limited by the applied cut-off voltage and the series resistance.









I Region of permissible operation during switching off with $-V_{BB}$ = 4 V; R_{BE} = 39 Ω
II Permissible extension for repetitive pulsed operation.
t_1 limits operations with $t_p \leq 0.1$ μs; $\delta = 0.25$
t_2 limits operations with $t_p \leq 1$ μs; $\delta = 0.25$
III Operation in this area is not allowed.

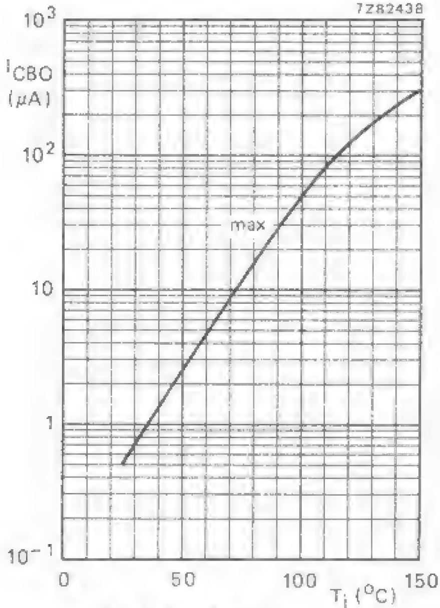


Fig. 9 V_{CB} = 40 V.

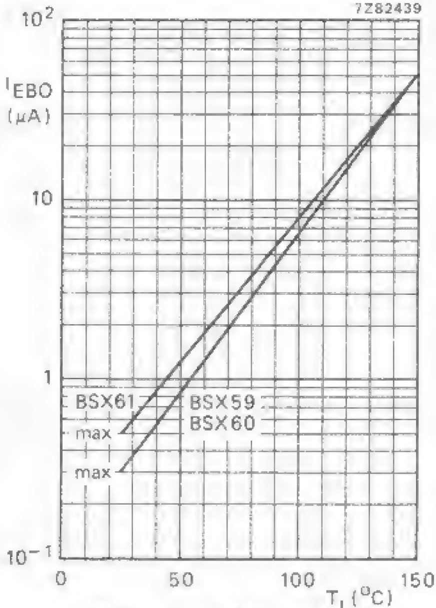


Fig. 10 V_{EB} = 4 V.

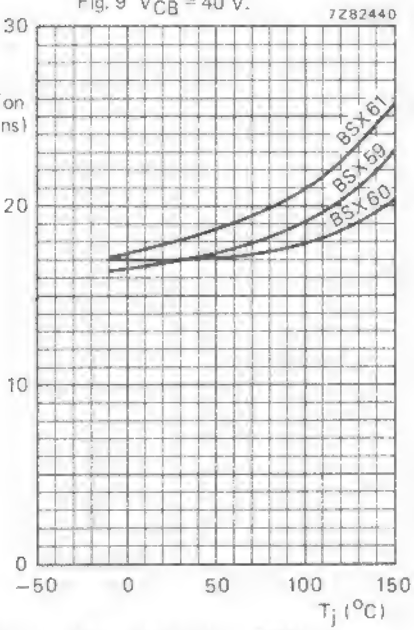


Fig. 11 $-V_{BEoff}$ = 2 V; I_{Con} = 500 mA; I_{Bon} = 50 mA; typ. values. (See also Fig. 4.)

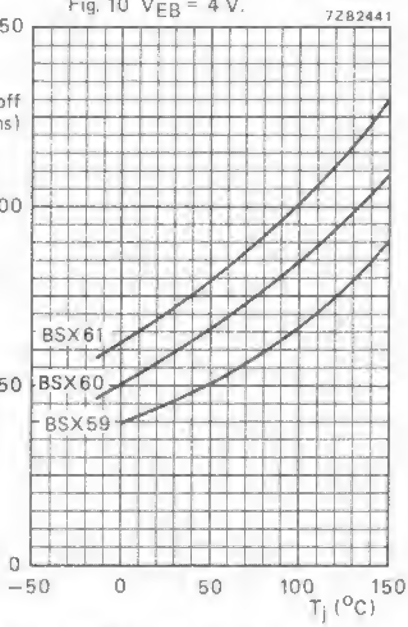


Fig. 12 I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 50 mA; typical values. (See also Fig. 4.)

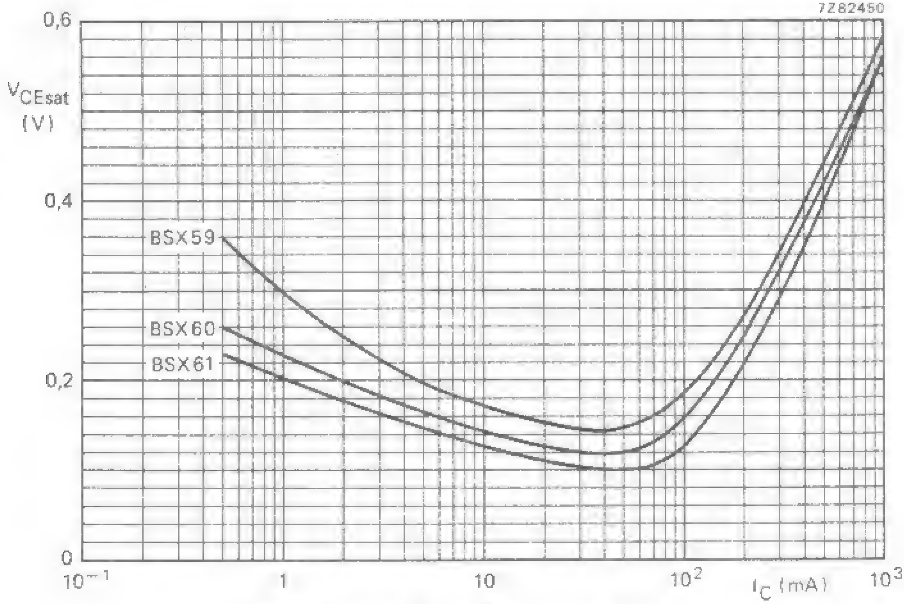


Fig. 13 $I_C/I_B = 10$; $T_j = 25\ ^oC$; typical values.

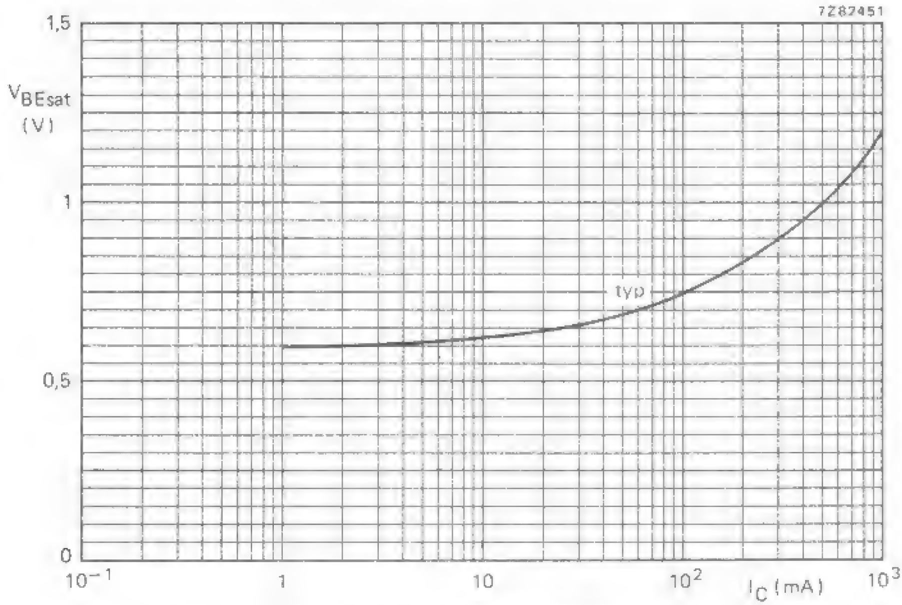


Fig. 14 $I_C/I_B = 10$; $T_j = 25\ ^oC$.

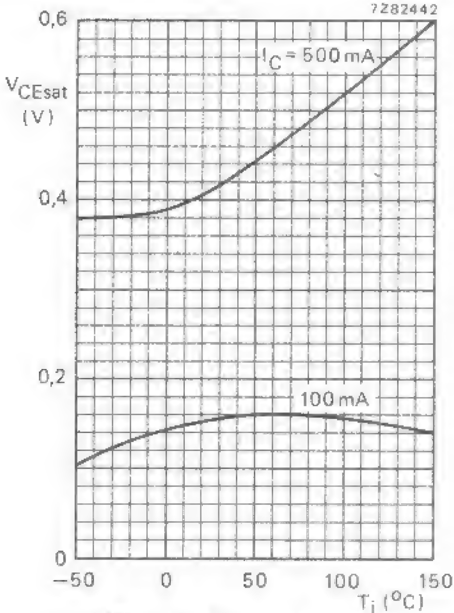


Fig. 15 $I_C/I_B = 10$; typical values.

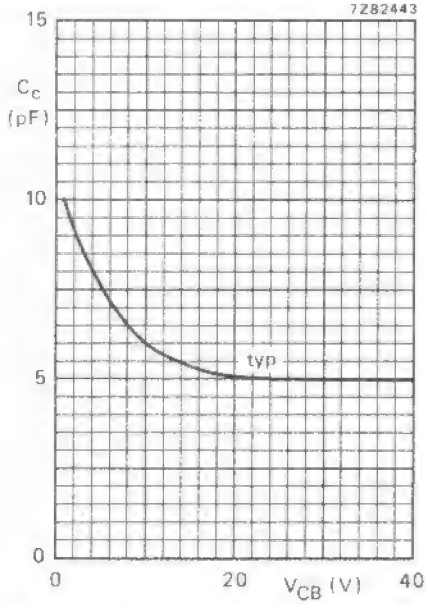


Fig. 16 $I_E = I_e = 0$; $f = 1$ MHz; $T_j = 25$ °C.

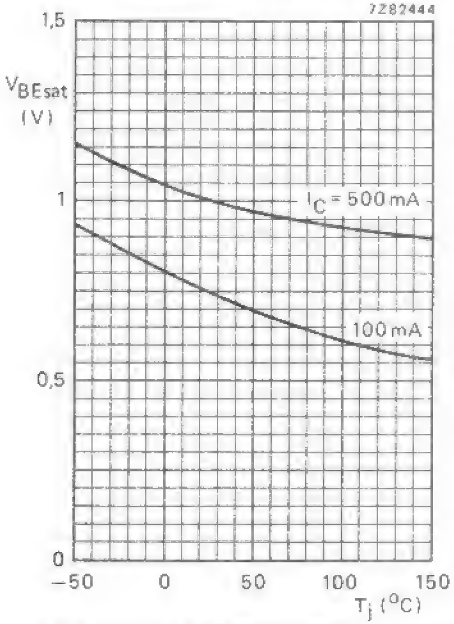


Fig. 17 $I_C/I_B = 10$; typical values.

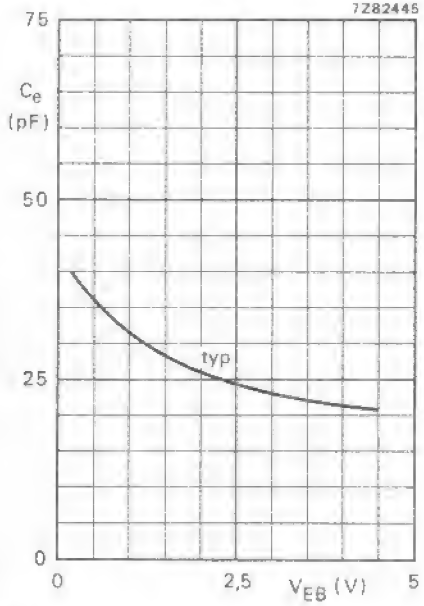


Fig. 18 $I_C = I_c = 0$; $f = 1$ MHz; $T_j = 25$ °C.

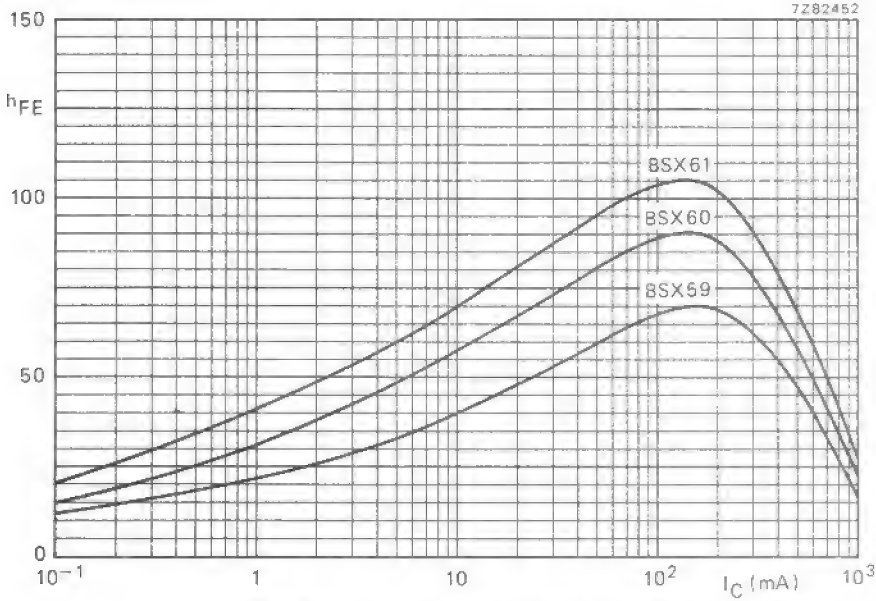


Fig. 19 V_{CE} = 1 V; T_j = 25 °C; typical values.

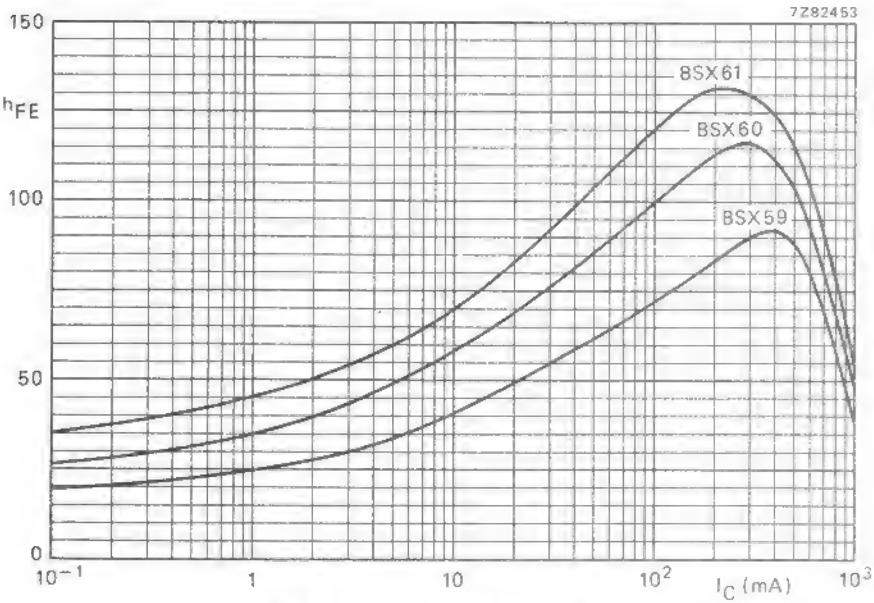


Fig. 20 V_{CE} = 5 V; T_j = 25 °C; typical values.

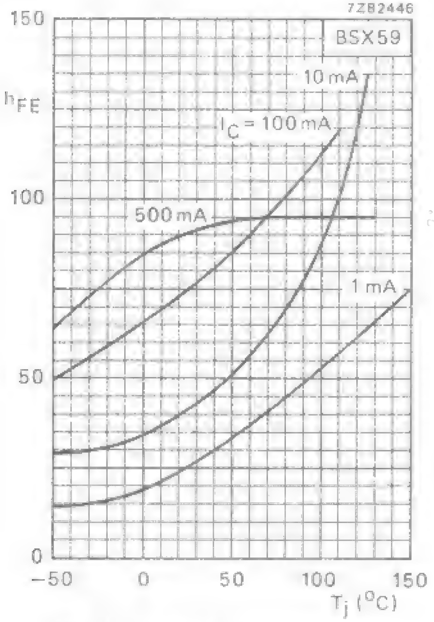


Fig. 21 V_{CE} = 5 V; typical values.

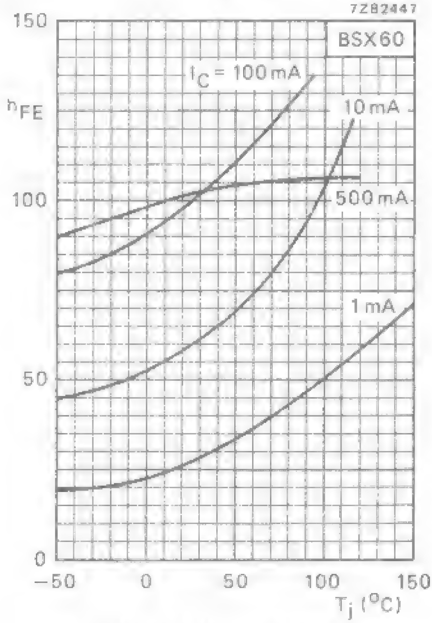


Fig. 22 V_{CE} = 5 V; typical values.

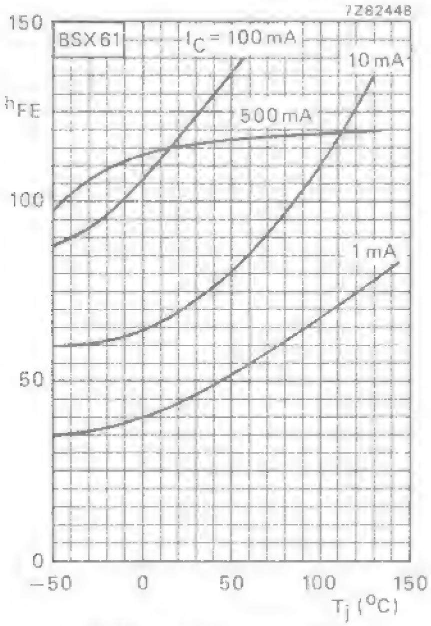


Fig. 23 V_{CE} = 5 V; typical values.

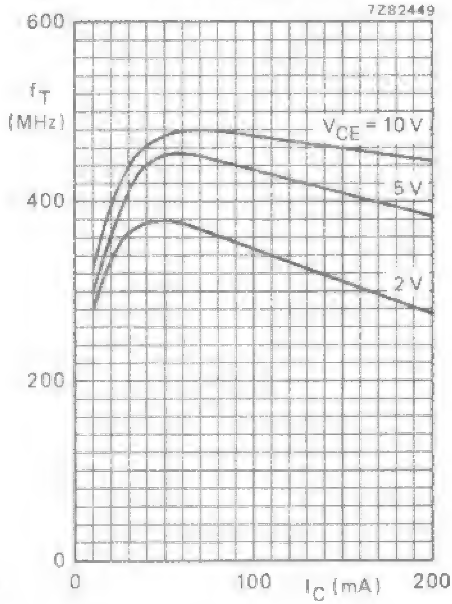


Fig. 24 f = 100 MHz; T_j = 25 °C; typ. values.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope intended for general purpose low level switching applications.

QUICK REFERENCE DATA

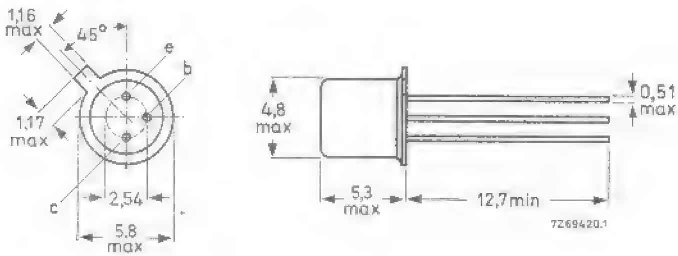
Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
D.C. current gain I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}		50 to 200	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 9,0 V	f_T	>	200	MHz
Storage time	t_s	<	50	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	20	V
V_{CEO} max.	15	V
V_{EBO} max.	5.0	V
*$I_{C(AV)}$ max.	100	mA
I_{CM} max.	200	mA
P_{tot} max. ($T_{amb} \leq 25^{\circ}C$)	300	mW

*Averaged over any 20ms period.

Temperature

T_{stg} min.	-65	$^{\circ}C$
T_{stg} max.	175	$^{\circ}C$
T_j max. (operating)	175	$^{\circ}C$

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	0.5	degC/mW

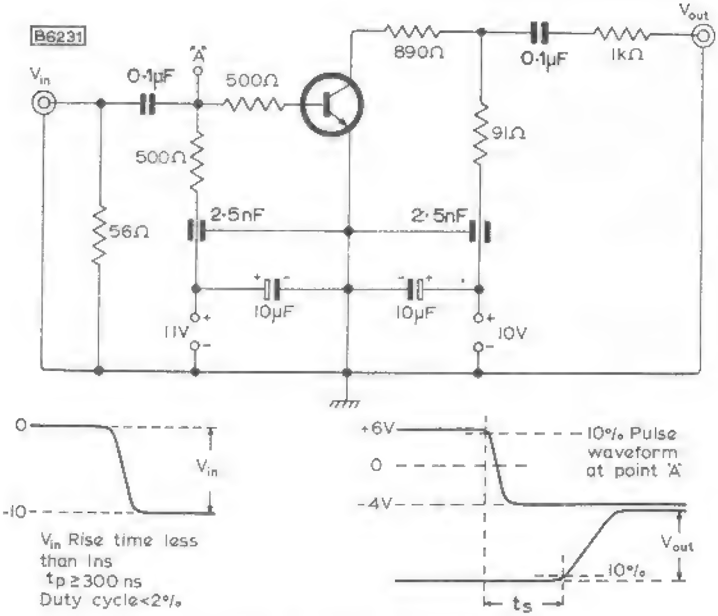
ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{\circ}C$ unless otherwise stated)

		Min.	Max.	
I_{CBO}	Collector cut-off current $V_{CB} = 16V$, $I_E = 0$	-	50	nA
$V_{BR(CBO)}$	Collector-base breakdown voltage $I_C = 1.0\mu A$	20	-	V
I_{EBO}	Emitter cut-off current $V_{EB} = 1.5V$, $I_C = 0$	-	25	nA
$V_{(BR)EBO}$	Emitter-base breakdown voltage $I_E = 10\mu A$	5.0	-	V
I_{CEO}	Collector-emitter cut-off current $V_{CE} = 12V$, $I_B = 0$	-	250	nA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage $I_C = 10mA$**	15	-	V
f_T	Transition frequency $I_C = 10mA$, $V_{CE} = 9.0V$, f = 100MHz	200	-	MHz

**Pulsed: Pulse width = 300µs, duty cycle < 2%.

		Min.	Max.	
h_{FE}	Common emitter forward current transfer ratio			
	I_C=1.0mA, V_{CE}=0.35V	30	-	
	I_C=10mA, V_{CE}=0.35V	50	200	
$V_{CE(sat)}$	Collector-emitter saturation voltage			
	I_C=10mA, I_B=0.2mA	-	0.35	V
$V_{BE(sat)}$	Base-emitter saturation voltage			
	I_C=10mA, I_B=0.2mA	0.67	0.87	V
C_{ob}	Collector-base capacitance			
	V_{CB}=9.0V, I_E=0			
	f=1.0MHz	-	6.0	pF
t_s	Storage time			
	I_C=10mA	-	50	ns
	See test circuit on next page			

STORAGE TIME TEST CIRCUIT



Input and output waveforms

SILICON PLANAR EPITAXIAL TRANSISTORS

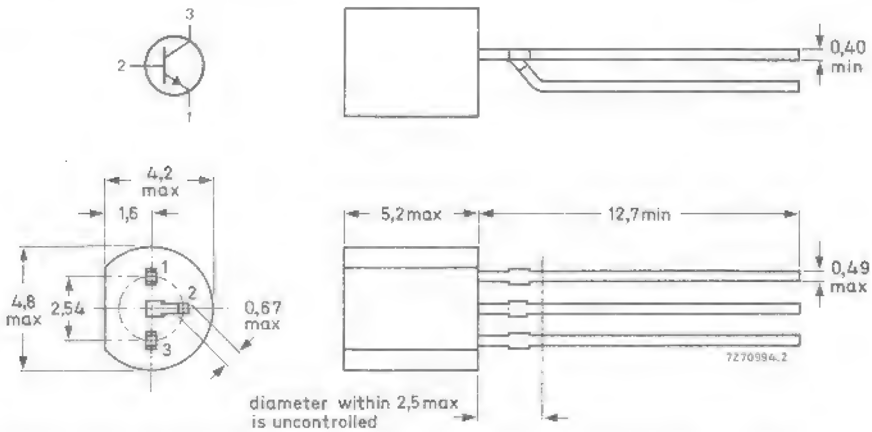
N-P-N transistors in plastic TO-92 variant envelopes, primarily intended for switching and linear applications.

QUICK REFERENCE DATA

			PH2222; R	PH2222A; R	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_{Con} = 150 mA; I_{Bon} = $-I_{Boff}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA of **PH2222** and **PH2222A** Dimensions in mm

Fig. 1 TO-92 variant.



The **PH2222R** and **PH2222AR** are available on request; they have cbe pinning instead of ebc.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			PH2222; R	PH2222A; R	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V
Collector current (d.c.)	I_C	max.	800		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PH2222; R	PH2222A; R	
Collector cut-off current					
$I_E = 0$; V_{CB} = 50 V	I_{CBO}	<	10	–	nA
$I_E = 0$; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	–	μA
$I_E = 0$; V_{CB} = 60 V	I_{CBO}	<	–	10	nA
$I_E = 0$; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA
Breakdown voltages					
$I_E = 0$; I_C = 10 μA	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; I_C = 10 mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; I_E = 10 μA	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages *					
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	0,4	0,3	V
	V_{BEsat}	>	–	0,6	V
		<	1,3	1,2	V
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	1,6	1,0	V
	V_{BEsat}	<	2,6	2,0	V

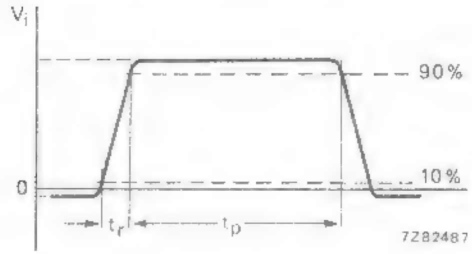
* Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta \leq 0{,}02$.

			PH2222; R	PH2222A; R	
D.C. current gain					
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	>	50	50	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = −55 °C	h_{FE}	>	–	35	
I_C = 150 mA; V_{CE} = 1 V*	h_{FE}	>	50	50	
I_C = 150 mA; V_{CE} = 10 V*	h_{FE}	>	100	100	
		<	300	300	
I_C = 500 mA; V_{CE} = 10 V*	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	–	25	pF
Feedback time constant at f = 31,8 MHz					
I_C = 20 mA; V_{CE} = 20 V	$r_{bb'} C_{b'c}$	<	–	150	ps
h-parameters (common emitter)					
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz					
Input impedance	h_{ie}	>	–	2	kΩ
		<	–	8	kΩ
Reverse voltage transfer ratio	h_{re}	<	–	8	10^{-4}
Small-signal current gain	h_{fe}	>	–	50	
		<	–	300	
Output admittance	h_{oe}	>	–	5	μA/V
		<	–	35	μA/V
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz					
Input impedance	h_{ie}	>	–	0,25	kΩ
		<	–	1,25	kΩ
Reverse voltage transfer ratio	h_{re}	<	–	4	10^{-4}
Small-signal current gain	h_{fe}	>	–	75	
		<	–	375	
Output admittance	h_{oe}	>	–	25	μA/V
		<	–	200	μA/V
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz					
Small-signal current gain	h_{fe}	>	2,5	3,0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz					
Real part of input impedance	$Re(h_{ie})$	<	60	60	Ω
Noise figure at f = 1 kHz					
I_C = 0,1 mA; V_{CE} = 10 V					
R_G = 1 kΩ; B = 1 Hz	F	<	–	4	dB

* Measured under pulse conditions: $t_p \leq 300$ μs; $\delta \leq 0,02$.

Switching times (between 10% and 90% levels) for **PH2222A; R**

Turn-on time when switched to I_{Con} = 150 mA (see Fig. 2)			
delay time	t_d	<	10 ns
rise time	t_r	<	25 ns
Turn-off time when switched from I_{Con} = 150 mA (see Fig. 3)			
storage time	t_s	<	225 ns
fall time	t_f	<	60 ns



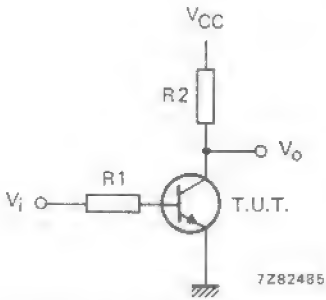
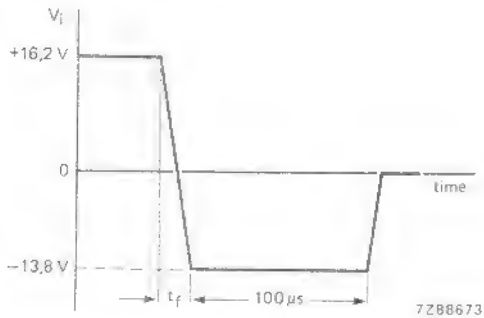


Fig. 2 Input waveform and test circuit for determining delay time and rise time.

V_i = –0,5 V to + 9,9 V; V_{CC} = + 30 V; R1 = 619 Ω; R2 = 200 Ω.

Pulse generator:				Oscilloscope:			
pulse duration	t_p	⩽	200 ns	input impedance	Z_i	>	100 kΩ
rise time	t_r	⩽	2 ns	input capacitance	C_i	<	12 pF
duty factor	δ	=	0,02	rise time	t_r	<	5 ns



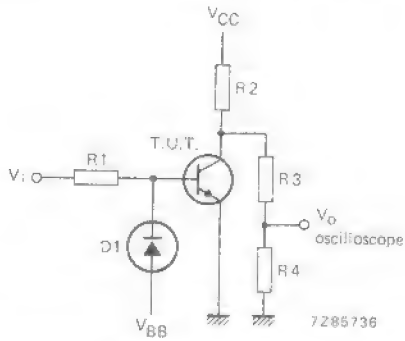


Fig. 3 Input waveform and test circuit for determining storage time and fall time.

V_{CC} = + 30 V; V_{BB} = –3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

Pulse generator:				Oscilloscope:			
fall time	t_f	<	5 ns	input impedance	Z_i	>	100 kΩ
				input capacitance	C_i	<	12 pF
				rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL SWITCHING TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope intended for high-speed switching applications.

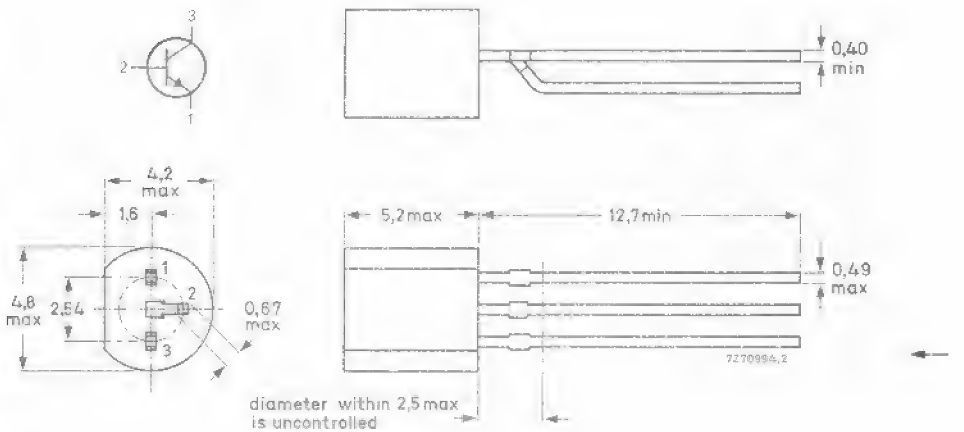
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	
$I_C = 100$ mA; $V_{CE} = 2$ V	h_{FE}	>	20	
Transition frequency at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	500	MHz
Storage time				
$I_{Con} = I_{Bon} = -I_{Boff} = 10$ mA	t_s	<	13	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40 V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40 V
Collector-emitter voltage (open base)	V_{CEO}	max.	15 V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5 V
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
→ Storage temperature	T_{stg}	−65 to + 150	°C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
I_E = 0; V_{CB} = 20 V	I_{CBO}	<	400 nA
I_E = 0; V_{CB} = 20 V; T_j = 125 °C	I_{CBO}	<	30 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 2 V	I_{EBO}	<	100 nA
Saturation voltages			
I_C = 10 mA; I_B = 0,3 mA	V_{CEsat}	<	0,30 V
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0,25 V
	V_{BEsat}	0,70 to	0,85 V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0,60 V
	V_{BEsat}	<	1,50 V
D.C. current gain			
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	40 to	120
I_C = 10 mA; V_{CE} = 1 V; T_{amb} = −55 °C	h_{FE}	>	20
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	20
Transition frequency at f = 100 MHz			
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500 MHz
Collector capacitance at f = 1 MHz			
I_E = I_e = 0; V_{CB} = 5 V	C_c	<	4 pF
Emitter capacitance at f = 1 MHz			
I_C = I_c = 0; V_{EB} = 1 V	C_e	<	4,5 pF

Switching times

Storage time (see Fig. 2)			
I_{Con} = I_{Bon} = $-I_{Boff}$ = 10 mA	t_s	typ.	6 ns
		<	13 ns

Pulse generator:

t_r	<	1 ns
t_p	>	300 ns
δ	<	0,02
R_s	=	50 Ω

Oscilloscope:

R_i = 50 Ω
t_r < 1 ns

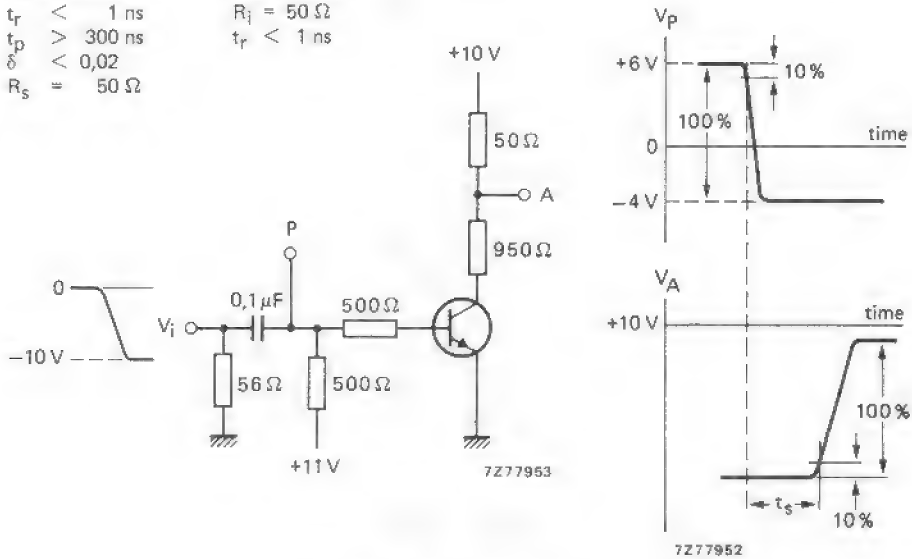


Fig. 2 Test circuit and waveforms.

Turn-on time (see Fig. 3)

from $-V_{BEoff}$ = 1,5 V to I_{Con} = 10 mA; I_{Bon} = 3 mA	t_{on}	<	12 ns
from $-V_{BEoff}$ = 2,25 V to I_{Con} = 100 mA; I_{Bon} = 40 mA	t_{on}	<	7 ns

Turn-off time (see Fig. 3)

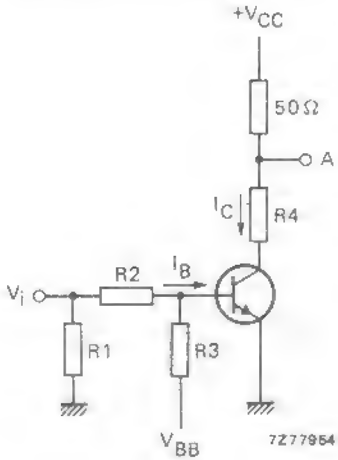
I_{Con} = 10 mA; I_{Bon} = 3 mA; $-I_{Boff}$ = 1,5 mA	t_{off}	<	18 ns
I_{Con} = 100 mA; I_{Bon} = 40 mA; $-I_{Boff}$ = 20 mA	t_{off}	<	21 ns

Pulse generator:

t_r < 1 ns
t_p > 300 ns
δ < 0,02
R_s = 50 Ω

Oscilloscope:

R_i = 50 Ω
t_r < 1 ns



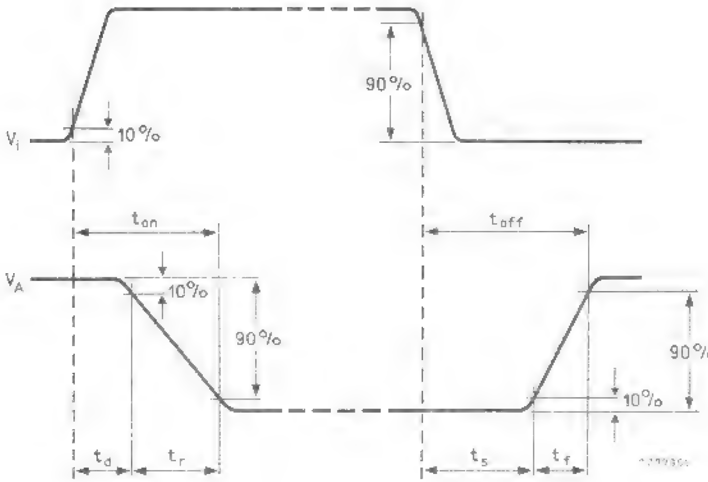


Fig. 3 Test circuit and waveforms.

							turn-on time			turn-off time	
I_{Con} mA	I_{Bon} mA	I_{Boff} mA	V_{CC} V	R1 Ω	R2; R3 kΩ	R4 Ω	V_{BB} V	V_{BE} V	V_i V	V_{BB} V	V_i V
10	3	−1,5	3	50	3,30	220	−3,0	−1,50	15	12,0	−15
100	40	−20	6	56	0,33	0	−4,5	−2,25	20	15,3	−20

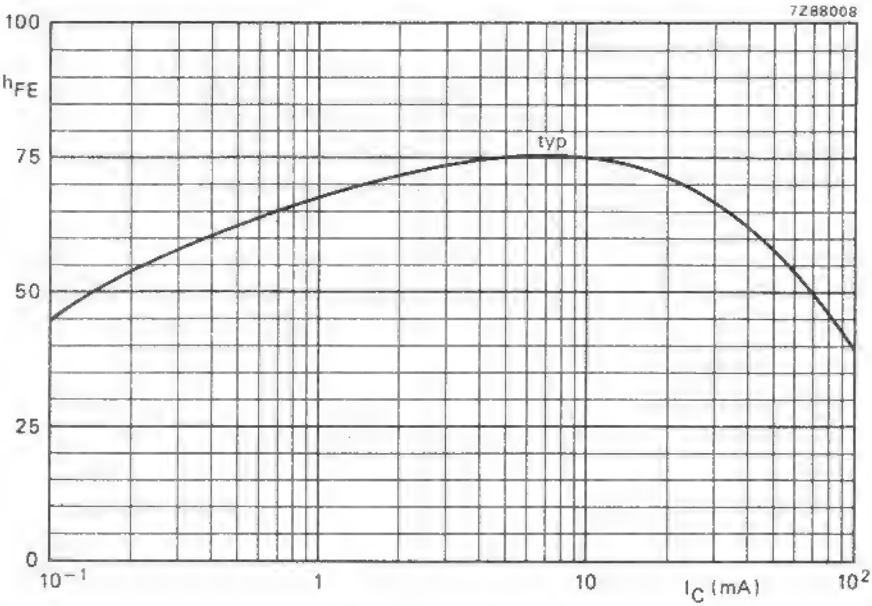


Fig. 4 V_{CE} = 1 V; T_j = 25 °C.

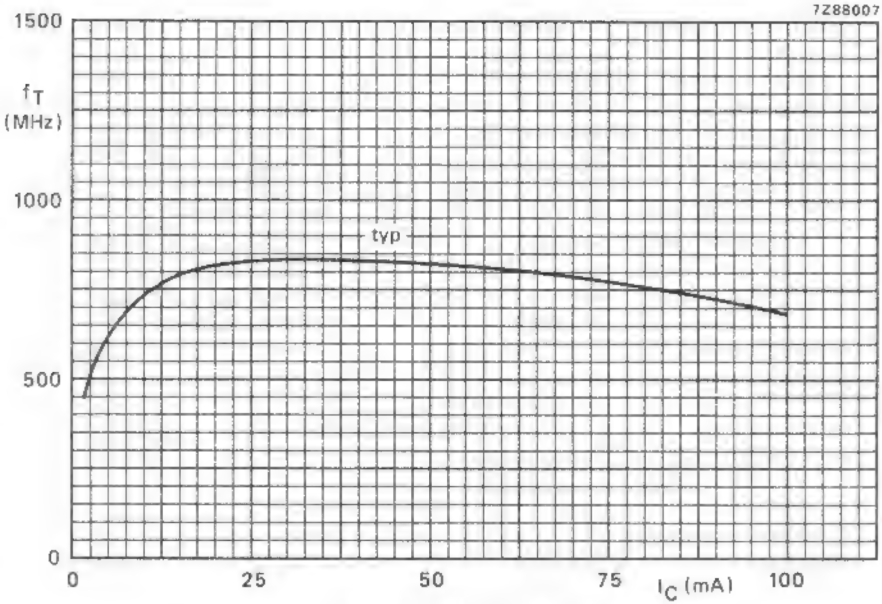


Fig. 5 V_{CE} = 10 V; T_j = 25 °C.

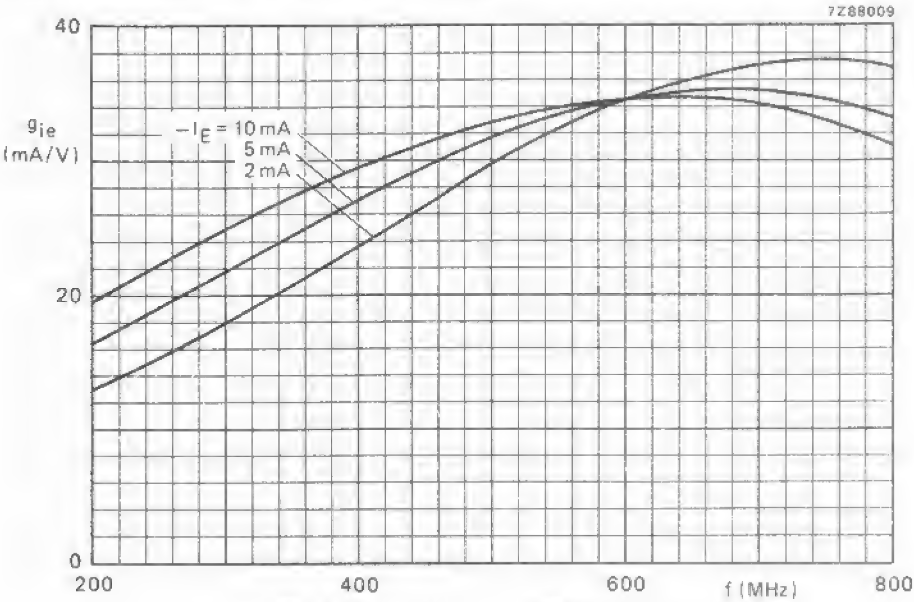


Fig. 6 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

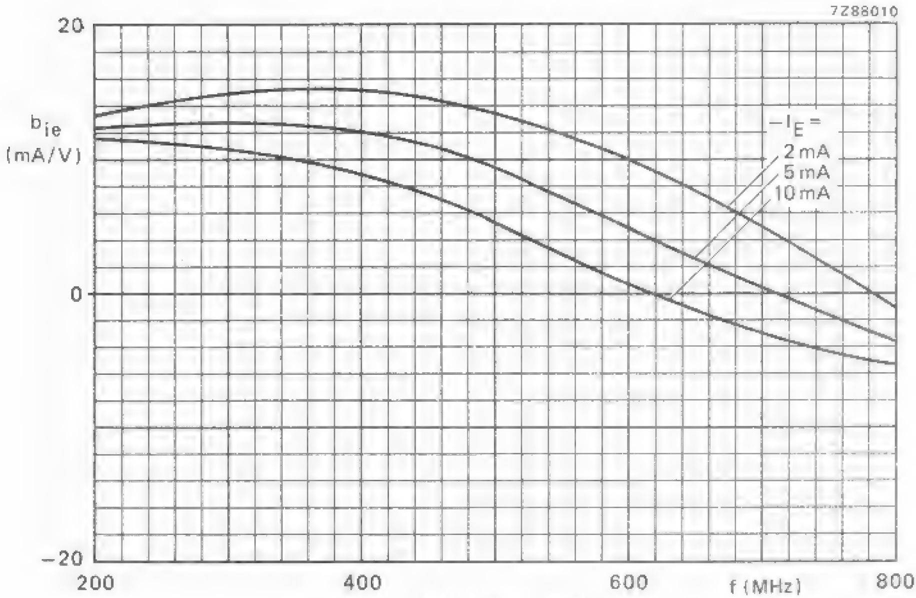


Fig. 7 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

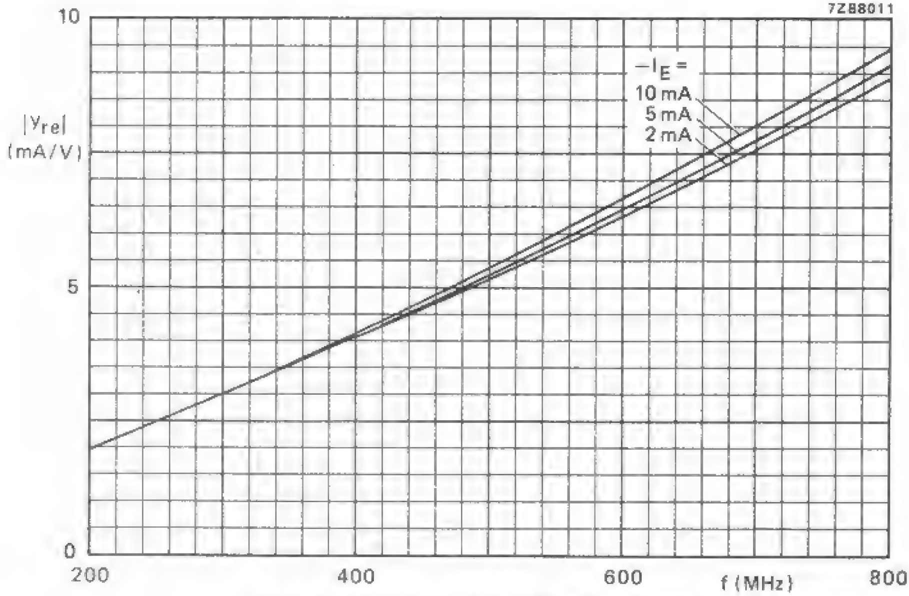


Fig. 8 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

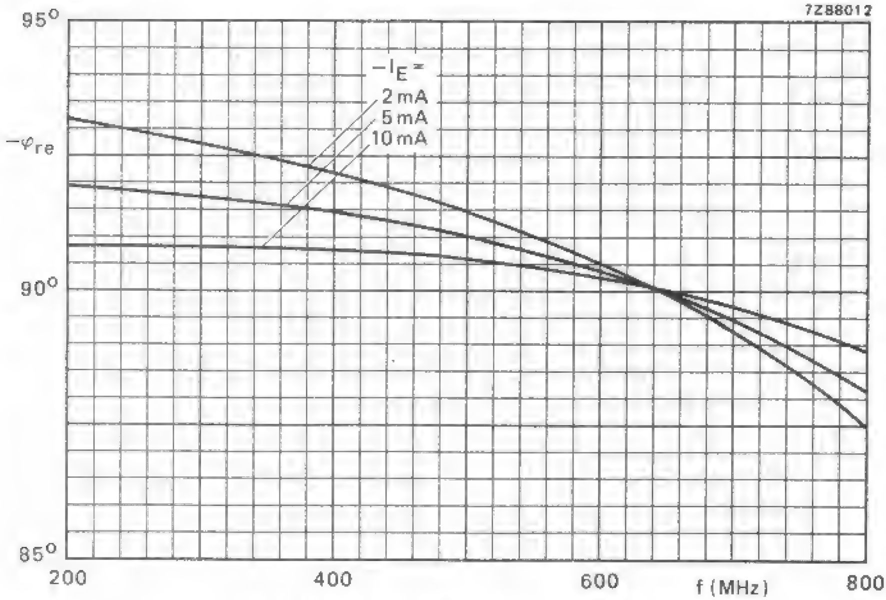


Fig. 9 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

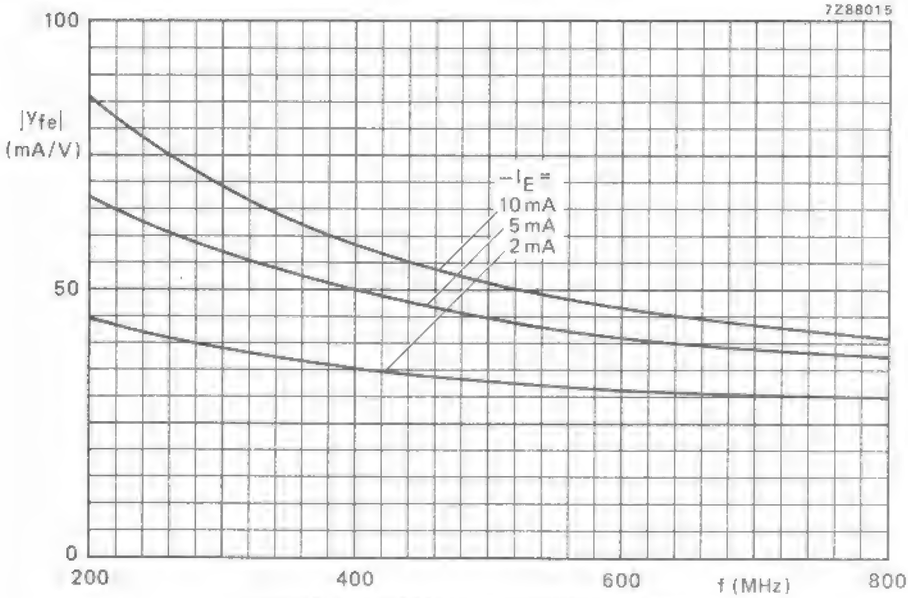


Fig. 10 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

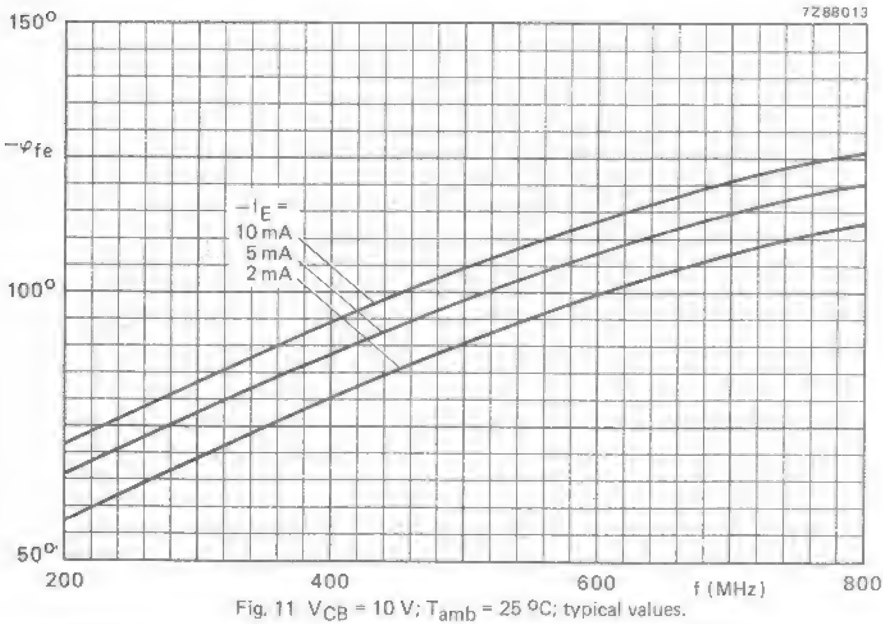


Fig. 11 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

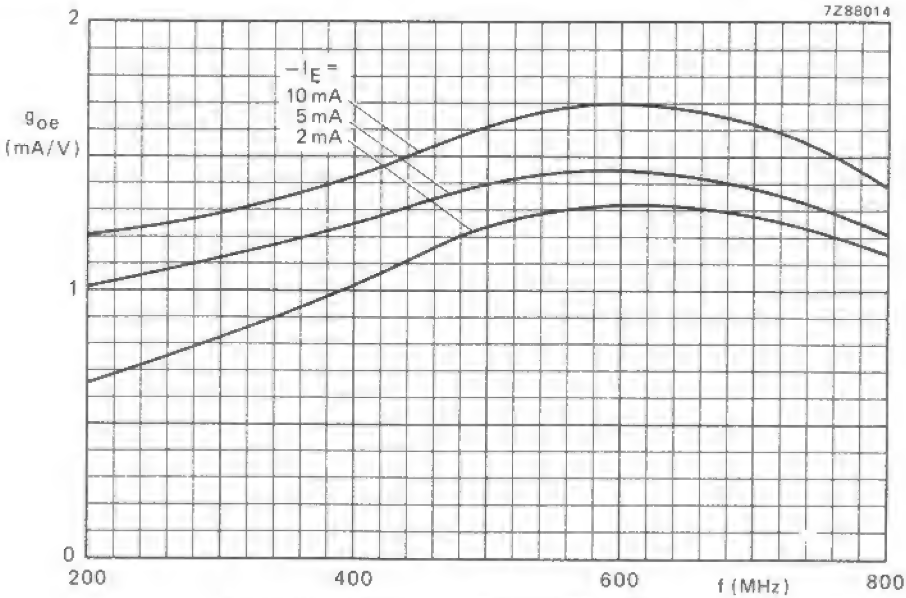


Fig. 12 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

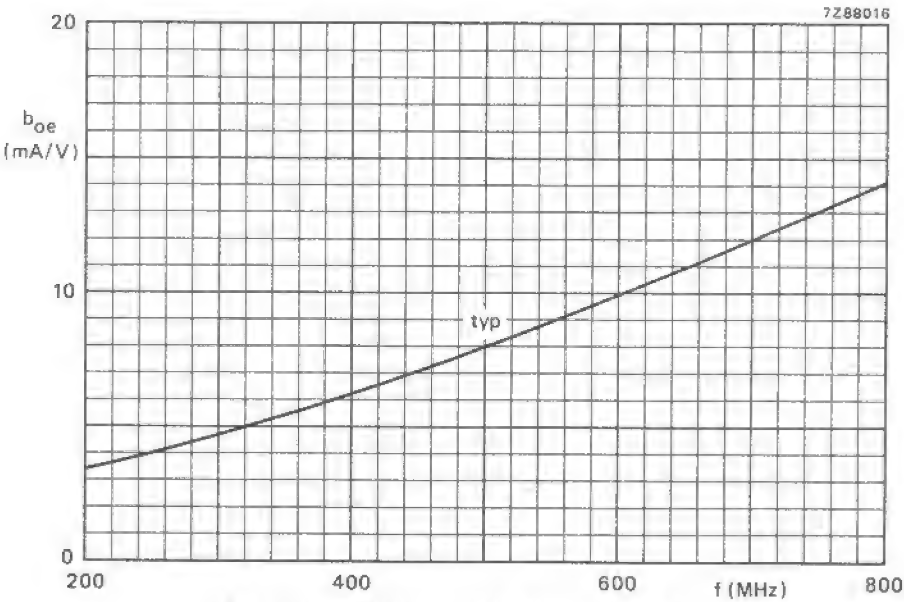


Fig. 13 V_{CB} = 10 V; $-I_E$ = 2 to 10 mA; T_{amb} = 25 °C.

SILICON PLANAR EPITAXIAL TRANSISTORS

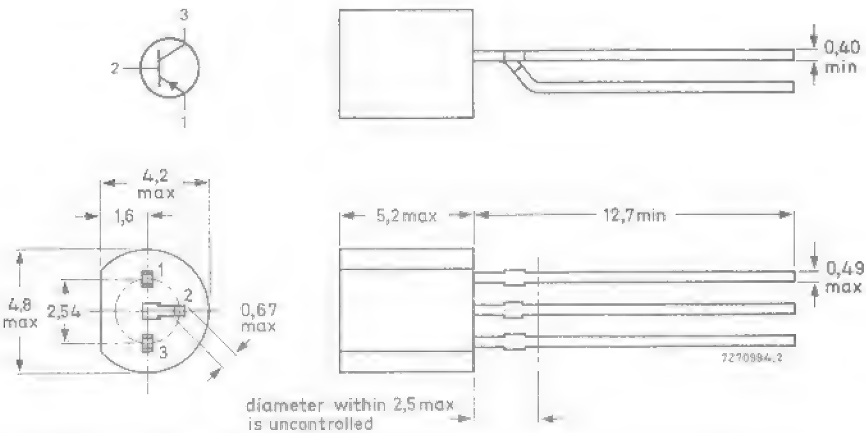
P-N-P medium power transistors in plastic TO-92 variant envelopes, primarily designed for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	PH2907; R	$-V_{CEO}$	max.	40	V
	PH2907A; R	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	625	mW
Junction temperature		T_j	max.	150	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}	100 to 300		
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	ns

MECHANICAL DATA of **PH2907** and **PH2907A** — Dimensions in mm

Fig. 1 TO-92 variant.



The **PH2907R** and **PH2907AR** are available on request; they have cbe pinning instead of ebc.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	**PH2907; R**	$-V_{CEO}$	max.	40 V
	PH2907A; R	$-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	625 mW
Storage temperature		T_{stg}	−65 to + 150 °C	
Junction temperature		T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2907; R	2N2907A; R	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage*					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages*					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100	
$-I_C = 150$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	100	100	
		<	300	300	
$-I_C = 500$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	30	50	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V*	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-on time (see Fig. 2)
when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

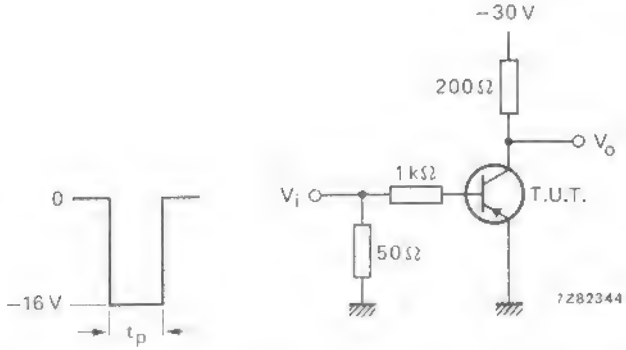


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)
when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

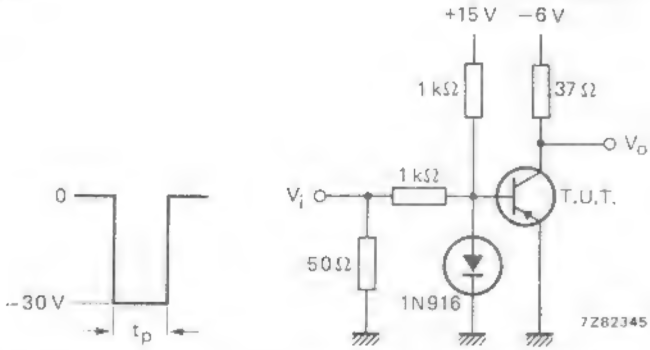


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150	Hz
pulse duration	t_p	=	200	ns
rise time	t_r	≤	2	ns
output impedance	Z_o	=	50	Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	≤	5	ns
input impedance	Z_i	≤	10	MΩ

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

P-N-P high-voltage small-signal transistors, primarily intended for use in telephony applications and encapsulated in a TO-92 variant envelope.

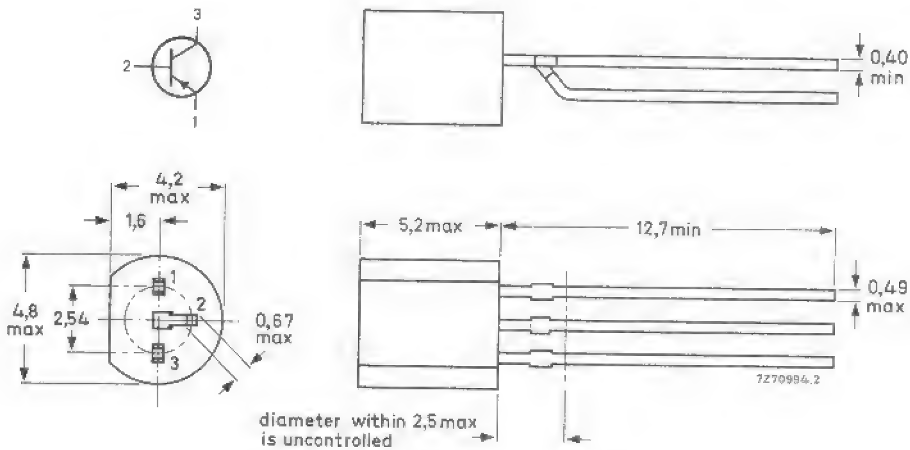
QUICK REFERENCE DATA

			PH5415	PH5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current	$-I_C$	max.	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage $-I_C$ = 50 mA; $-I_B$ = 5 mA	V_{CEsat}	<	2,5	2,0	V
D.C. current gain $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	30	
		<	150	120	

MECHANICAL DATA

Dimension in mm

Fig. 1 TO-92 variant.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			PH5415	PH5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current	$-I_C$	max.	1		A
Base current	$-I_B$	max.	500		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500		mW
Junction temperature	T_j	max.	150		°C

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			PH5415	PH5416	
Collector cut-off current					
$I_E = 0$; $-V_{CB}$ = 175 V	$-I_{CBO}$	<	50		μA
$I_E = 0$; $-V_{CB}$ = 280 V	$-I_{CBO}$	<		50	μA
Saturation voltages					
$-I_C$ = 50 mA; I_B = 5 mA	$-V_{CEsat}$	<	2,5	2,0	V
	$-V_{BEsat}$	<	1,5	1,5	V
D.C. current gain					
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	30	
	h_{FE}	<	150	120	
Transition frequency	f_T	>	15	15	MHz

N-P-N SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

These devices are primarily intended for use in high performance, low-level, low-noise amplifier applications both for direct current and for frequencies of up to 100 MHz.

QUICK REFERENCE DATA

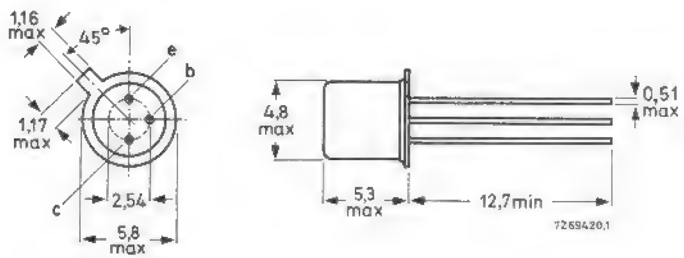
			2N929	2N930	
Collector-base voltage (open emitter)	V_{CBO}	max	45	45	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	45	V
Collector current (peak value)	I_{CM}	max	60	60	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	mW
Junction temperature	T_j	max	175	175	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
		<	120	300	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	100	150	
		<	350	600	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ					
I_C = 10 μA; V_{CE} = 5 V		typ	2,5	2	dB
f = 10 Hz to 15 kHz	F	<	4	3	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector-emitter voltage at $V_{EB} = 0$	V_{CES}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c. or average over any 50 ms period)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	60	mA
Emitter current (d.c. or average over any 50 ms period)	$-I_E$	max.	35	mA
Emitter current (peak value)	$-I_{EM}$	max.	70	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.25	$^oC/mW$

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	<	10	nA
$I_B = 0$; $V_{CE} = 5$ V	I_{CEO}	<	2	nA
$V_{EB} = 0$; $V_{CB} = 45$ V	I_{CES}	<	10	nA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA

Emitter-base voltage

$-I_E = 0.5$ mA; $V_{CB} = 5$ V	$-V_{EB}$	0.6 to 0.8	V

Saturation voltages

$I_C = 10$ mA; $I_B = 0.5$ mA	V_{CEsat}	<	1	V
	V_{BEsat}	0.6 to	1	V

		2N929	2N930	
D.C. current gain				
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	h_{FE}	40 to 120	100 to 300	
$I_C = 10\ \mu A$; $V_{CE} = 5$ V; $T_j = -55\ ^oC$	h_{FE}	> 10	> 20	
$I_C = 500\ \mu A$; $V_{CE} = 5$ V	h_{FE}	> 60	> 150	
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	100 to 350	150 to 600	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	< 8	< 8	pF
Transition frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	> 50	> 50	MHz
Cut-off frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_{hfe}	> 200	> 100	kHz

CHARACTERISTICS (continued) $T_j = 25\ ^{o}C$ unless otherwise specified

		2N929	2N930	
Noise figure (f = 10 Hz to 15 kHz)				
$I_C = 10\ \mu A$; $V_{CE} = 5\ V$; $R_S = 10\ k\Omega$	F	typ. 2.5	2	dB
		< 4	3	dB
h parameters at f = 1 kHz				
$I_C = 1\ mA$; $V_{CE} = 5\ V$				
Input impedance	h_{ie}	typ. 5.0	10.0	kΩ
Reverse voltage transfer	h_{re}	typ. 2.5	5.5	10^{-4}
Small signal current gain	h_{fe}	typ. 200	350	
		60 to 350	150 to 600	
Output admittance	h_{oe}	typ. 14	25	$\mu\Omega^{-1}$

SILICON PLANAR TRANSISTOR

N-P-N double diffused transistor in a TO-39 metal envelope designed for a wide variety of applications including d.c. amplifiers, high-speed switching and high-speed amplifiers.

QUICK REFERENCE DATA

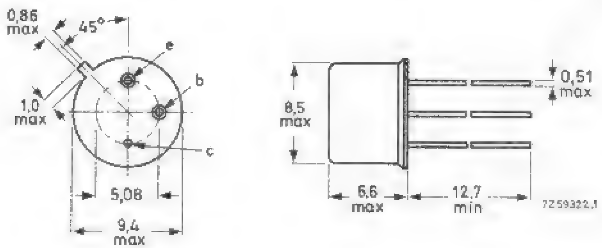
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 10 V	h_{FE}		40 to 120	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-104, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Collector current (peak value)*	I_{CM}	max.	500	mA
Total power dissipation				
up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
at T_{case} = 100 °C	P_{tot}	max.	1,7	W
up to T_{case} = 25 °C	P_{tot}	max.	3,0	W
Storage temperature	T_{stg}	−65 to +200		°C
Junction temperature	T_j	max.	200	°C
Lead soldering temperature $>$ 1,5 mm from the seating plane; $t_{sld} < 10$ s.	T_{sld}	max.	300	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	58,3	K/W

* With the exception of the collector current all other data are Jedec registered.

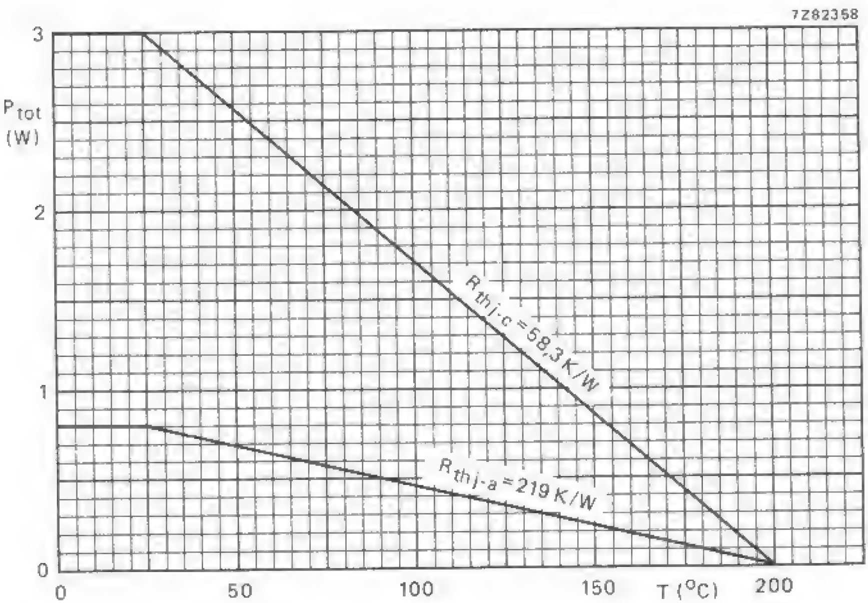


Fig. 2 Maximum permissible total power dissipation as a function of temperature.

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	10 nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	10 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10 nA
Collector-base breakdown voltage			
open emitter; I_C = 100 μA	$V_{(BR)CBO}$	>	75 V
Collector-emitter breakdown voltage*			
I_C = 100 mA; $R_{BE} \leqslant$ 10 Ω	$V_{(BR)CER}$	>	50 V
Emitter-base breakdown voltage			
open collector; I_E = 100 μA	$V_{(BR)EBO}$	>	7 V
Saturation voltages*			
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	1,5 V
	V_{BEsat}	<	1,3 V
D.C. current gain			
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	20
I_C = 10 mA; V_{CE} = 10 V*	h_{FE}	>	35
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = −55 °C	h_{FE}	>	20
I_C = 150 mA; V_{CE} = 10 V*	h_{FE}		40 to 120
I_C = 500 mA; V_{CE} = 10 V*	h_{FE}	>	20
Transition frequency at f = 20 MHz			
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60 MHz
Collector capacitance			
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	25 pF
Emitter capacitance			
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	80 pF
Noise figure at f = 1 kHz			
I_C = 0,3 mA; V_{CE} = 10 V; R_S = 510 Ω; B = 1 Hz	F	<	12 dB

h-parameters at f = 1 kHz

Input impedance			
I_C = 1 mA; V_{CB} = 5 V	h_{ib}		24 to 34 Ω
I_C = 5 mA; V_{CB} = 10 V	h_{ib}		4 to 8 Ω
Reverse voltage transfer ratio			
I_C = 1 mA; V_{CE} = 5 V	h_{rb}	<	$3 \; 10^{-4}$
I_C = 5 mA; V_{CE} = 10 V	h_{rb}	<	$3 \; 10^{-4}$
Small-signal current gain			
I_C = 1 mA; V_{CE} = 5 V	h_{fe}		30 to 100
I_C = 5 mA; V_{CE} = 10 V	h_{fe}		35 to 150

* Measured under pulse conditions to avoid excessive dissipation: t_p = 300 μs; $\delta \leqslant$ 0,02.

Output admittance		
I_C = 1 mA; V_{CE} = 5 V	h_{ob}	0,05 to 0,5 μA/V
I_C = 5 mA; V_{CE} = 10 V	h_{ob}	0,05 to 0,5 μA/V
Total switching time (see Figs 3 to 6)		
I_{Con} = 50 mA; $V_{BEon} = -V_{BEoff}$ = 1 V	$t_{on} + t_{off}$	< 30 ns

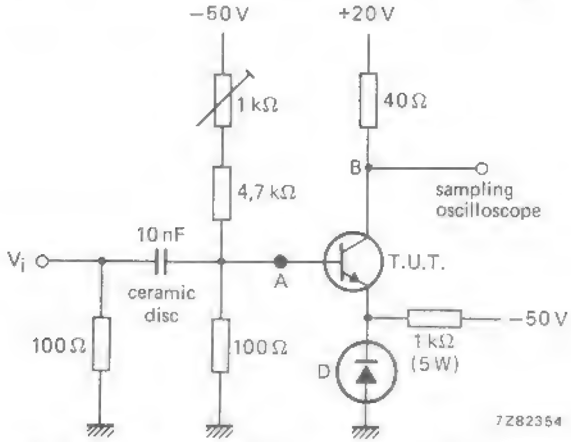


Fig. 3 Turn-on plus turn-off measuring circuit. D = BAW62.

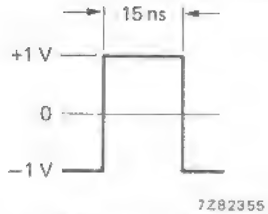


Fig. 4 Waveform at "A".
Pulse generator: t_r; t_f < 1 ns.

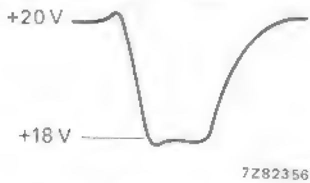


Fig. 5 Waveform at "B".

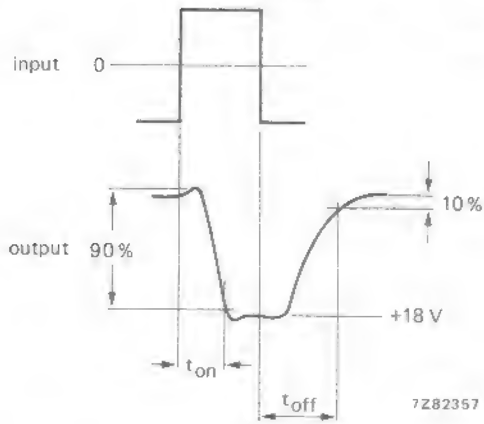


Fig. 6 Turn-on and turn-off time.

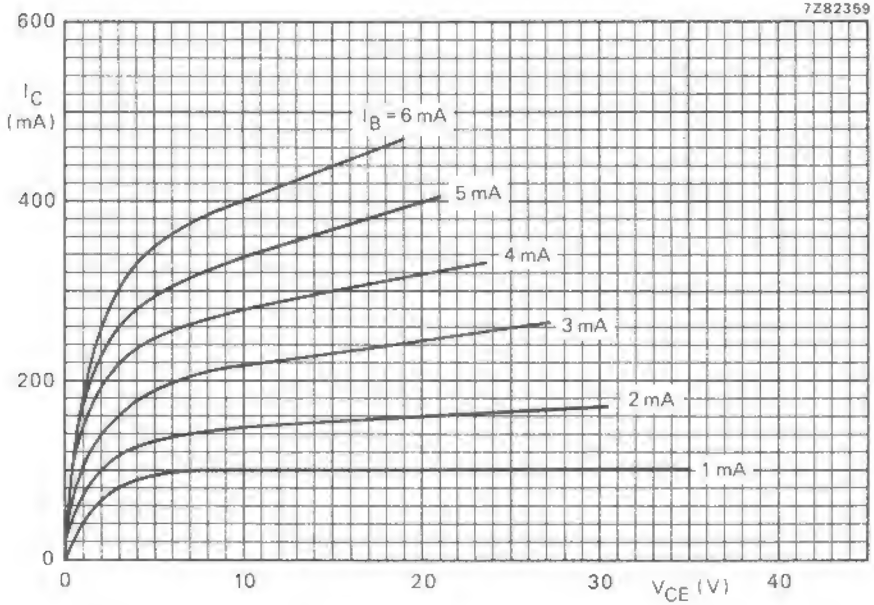


Fig. 7 T_j = 25 °C; typical values.

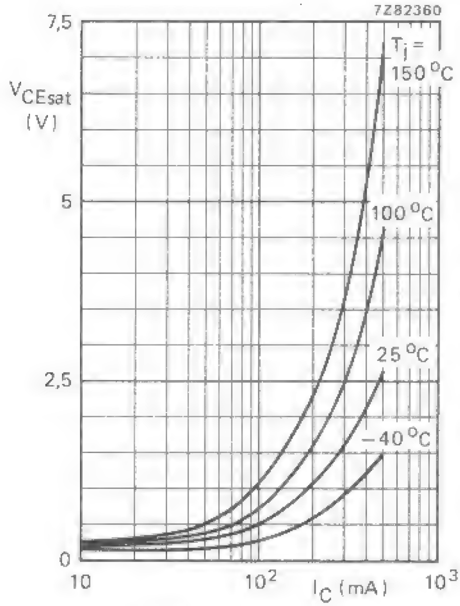


Fig. 8 I_C/I_B = 10; typical values.

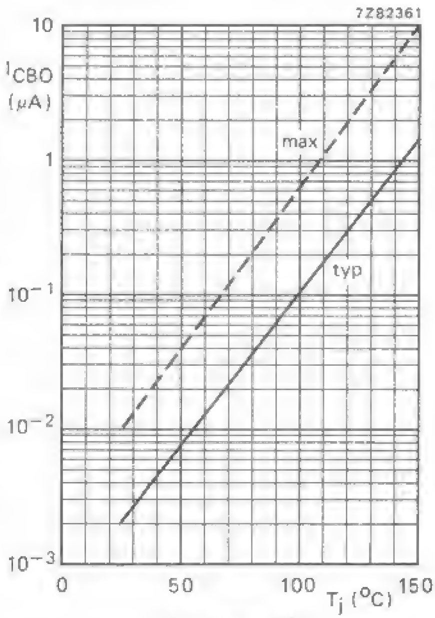


Fig. 9 V_{CB} = 60 V.

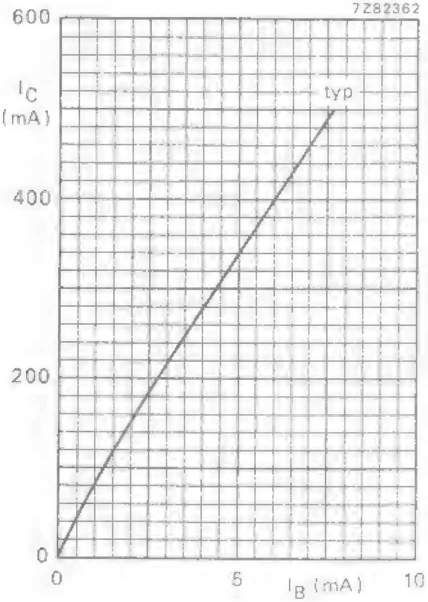


Fig. 10 V_{CE} = 10 V; T_j = 25 °C.

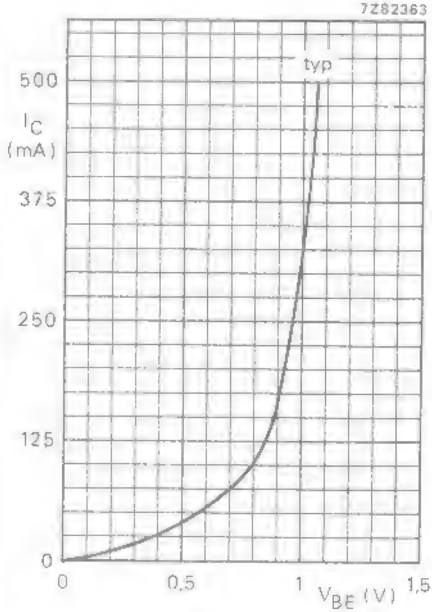


Fig. 11 V_{CE} = 10 V; T_j = 25 °C.

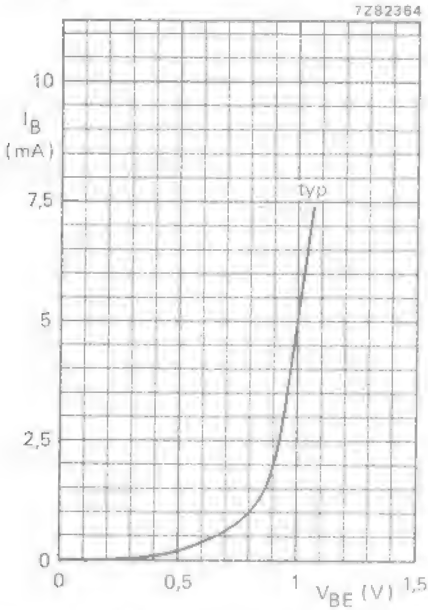


Fig. 12 V_{CE} = 10 V; T_j = 25 °C.

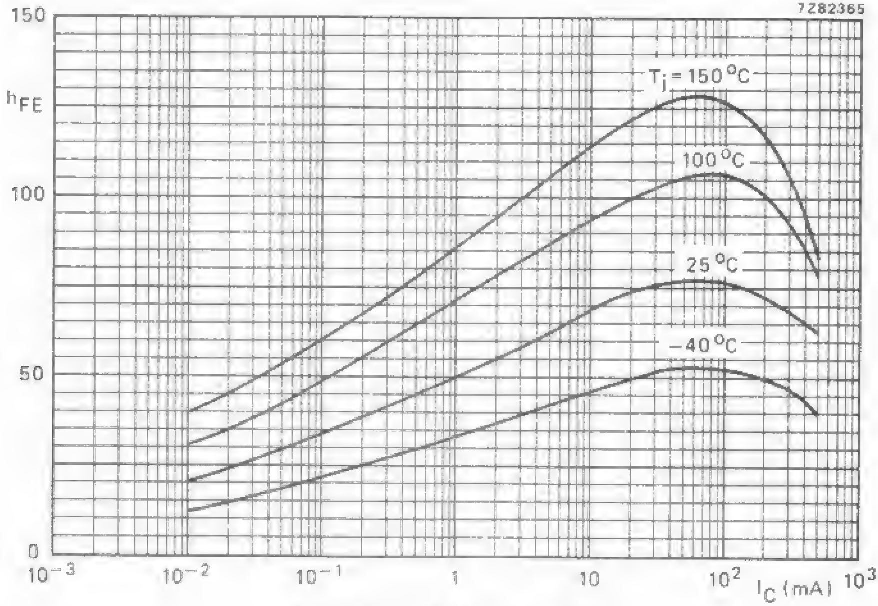


Fig. 13 $V_{CE} = 10$ V; typical values.

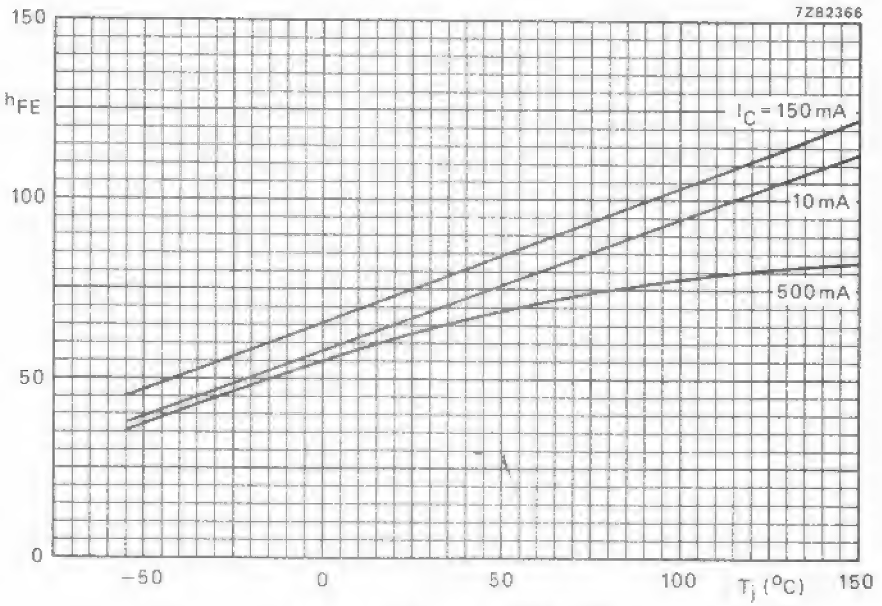


Fig. 14 $V_{CE} = 10$ V; typical values.

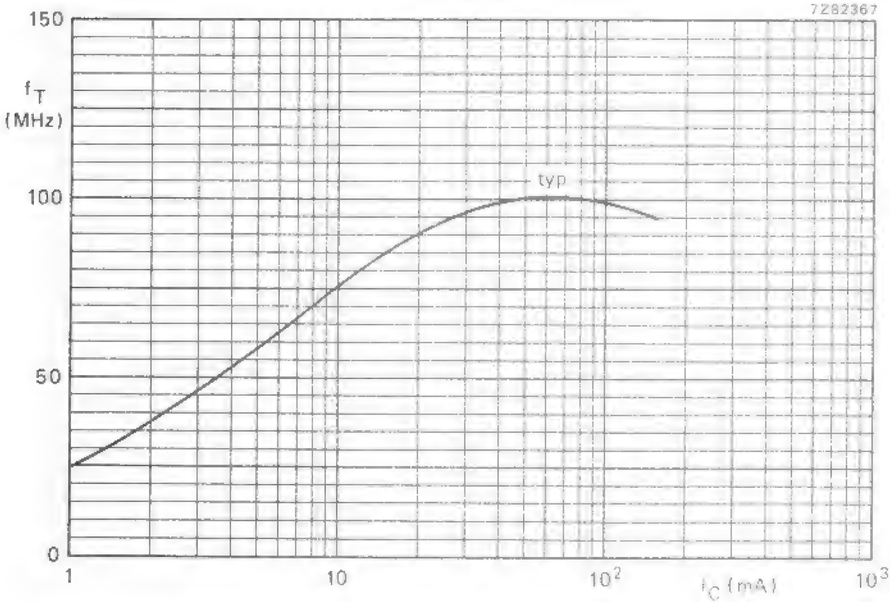


Fig. 15 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

SILICON PLANAR TRANSISTOR

N-P-N double diffused transistor in a TO-39 metal envelope designed for a wide variety of applications such as d.c. and wideband amplifiers.

QUICK REFERENCE DATA

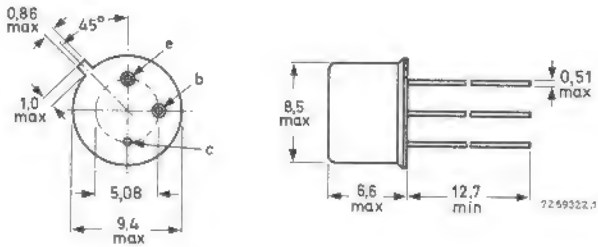
Collector-base voltage (open emitter)	V_{CBO}	max.	75 V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50 V
Collector current (peak value)	I_{CM}	max.	1,0 A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8 W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		100 to 300
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	70 MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-104, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7,0	V
Collector current (peak value)	I_{CM}	max.	1,0	A
Total power dissipation				
up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0,8	W
up to $T_{case} = 100\ ^oC$	P_{tot}	max.	1,7	W
up to $T_{case} = 25\ ^oC$	P_{tot}	max.	3,0	W
Storage temperature	T_{stg}	−65 to + 200		^oC
Junction temperature	T_j	max.	200	^oC
Lead soldering temperature $>$ 1,5 mm from the seating plane; $t_{sld} < 10$ s	T_{sld}	max.	300	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	219	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58,3	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10 nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10 µA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5{,}0$ V	I_{EBO}	<	5 nA
Collector-base breakdown voltage			
open emitter; $I_C = 100$ µA	$V_{(BR)CBO}$	>	75 V
Emitter-base breakdown voltage			
open collector; $I_E = 100$ µA	$V_{(BR)EBO}$	>	7,0 V
Collector-emitter sustaining voltage *			
$I_C = 100$ mA; $R_{BE} \leqslant 10\ \Omega$	$V_{CERsust}$	>	50 V
Saturation voltages *			
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	1,5 V
	V_{BEsat}	<	1,3 V
D.C. current gain			
$I_C = 10$ µA ; $V_{CE} = 10$ V	h_{FE}	>	20
$I_C = 0{,}1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35
$I_C = 10$ mA; $V_{CE} = 10$ V *	h_{FE}	>	75
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	35
$I_C = 150$ mA; $V_{CE} = 10$ V *	h_{FE}		100 to 300
$I_C = 500$ mA; $V_{CE} = 10$ V *	h_{FE}	>	40
Transition frequency at f = 20 MHz			
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	70 MHz
Collector capacitance			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	25 pF
Emitter capacitance			
$I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	<	80 pF
Noise figure at f = 1 kHz			
$I_C = 300$ µA; $V_{CE} = 10$ V; $R_S = 510\ \Omega$; B = 1 Hz	F	<	8,0 dB

h-parameters at f = 1 kHz

Input impedance			
$I_C = 1{,}0$ mA; $V_{CB} = 5{,}0$ V	h_{ib}		24 to 34 Ω
$I_C = 5{,}0$ mA; $V_{CB} = 10$ V	h_{ib}		4,0 to 8,0 Ω
Reverse voltage transfer ratio			
$I_C = 1{,}0$ mA; $V_{CB} = 5{,}0$ V	h_{rb}	<	$5{,}0\ 10^{-4}$
$I_C = 5{,}0$ mA; $V_{CB} = 10$ V	h_{rb}	<	$5{,}0\ 10^{-4}$
Small-signal current gain			
$I_C = 1{,}0$ mA; $V_{CE} = 5{,}0$ V	h_{fe}		50 to 200
$I_C = 5{,}0$ mA; $V_{CE} = 10$ V	h_{fe}		70 to 300

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ µs; $\delta \leqslant 0{,}02$.

Output admittance		
I_C = 1,0 mA; V_{CE} = 5,0 V	h_{ob}	0,05 to 0,5 μA/V
I_C = 5,0 mA; V_{CE} = 10 V	h_{ob}	0,05 to 0,5 μA/V

SILICON TRANSISTOR

High voltage n-p-n transistor in a TO-39 metal envelope with the collector connected to the case. It is intended for use in high performance amplifier, oscillator and switching applications.

QUICK REFERENCE DATA

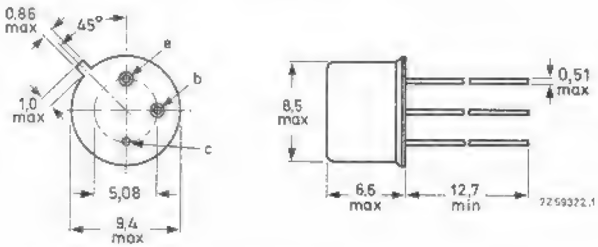
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	100	V
Collector current (d.c.)	I_C	max.	500	mA
Total power dissipation up to $T_{case} = 25\ ^oC$	P_{tot}	max.	3,0	W
Junction temperature	T_j	max.	200	^oC
D.C. current gain				
$I_C = 0,1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T = -55\ ^oC$	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	40 to	120	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-104, available on request.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max. 120	V
Collector-emitter voltage (open base)	V_{CEO}	max. 80	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max. 100	V
Emitter-base voltage (open collector)	V_{EBO}	max. 7.0	V

Current

Collector current (d.c.)	I_C	max. 500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max. 0.8	W
up to T_{case} = 100 °C	P_{tot}	max. 1.7	W
up to T_{case} = 25 °C	P_{tot}	max. 3.0	W

Temperatures

Storage temperature	T_{stg}	−65 to +200	°C
Junction temperature	T_j	max. 200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	= 219	°C/W
From junction to case	$R_{th\ j\text{-}c}$	= 58.3	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	15	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA

Collector-emitter sustaining voltage [1]

$I_C = 100$ mA; $R_{BE} \geq 10\ \Omega$	$V_{CER\ sust}$	>	100	V
$I_C = 30$ mA; $I_B = 0$	$V_{CEO\ sust}$	>	80	V

Saturation voltages [1]

$I_C = 150$ mA; $I_B = 15$ mA	$V_{CE\ sat}$	<	5.0	V
	$V_{BE\ sat}$	<	1.3	V
$I_C = 50$ mA; $I_B = 5$ mA	$V_{CE\ sat}$	<	1.2	V
	$V_{BE\ sat}$	<	0.9	V

Breakdown voltages

$I_E = 0$; $I_C = 100$ μA	$V_{(BR)\ CBO}$	>	120	V
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)\ EBO}$	>	7.0	V

D.C. current gain

$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20
$I_C = 10$ mA; $V_{CE} = 10$ V; $T = -55$ °C	h_{FE}	>	20
$I_C = 10$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	35
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}	40 to	120

[1] Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs, duty cycle $\delta < 0.02$

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

h parameters at f = 1 kHz (common base)			
I_C = 1 mA; V_{CE} = 5 V			
Input impedance	h_{ib}	20 to 30	Ω
Reverse voltage transfer ratio	h_{rb}	1.25	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
I_C = 5 mA; V_{CE} = 10 V			
Input impedance	h_{ib}	4 to 8	Ω
Reverse voltage transfer ratio	h_{rb}	1.50	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
Small signal current gain (common emitter)			
I_C = 1 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	30 to 100	
I_C = 5 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	> 45	
I_C = 50 mA; V_{CE} = 10 V; f = 20 MHz	h_{fe}	> 2.5	
Collector capacitance			
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	< 15	pF
Emitter capacitance			
$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	< 85	pF

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2219 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

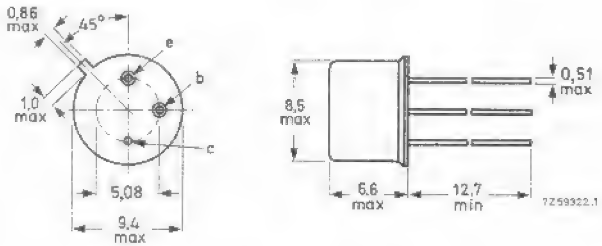
			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_C = 150 mA; $I_B = -I_{BM}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-029, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

<u>Voltages</u>

			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1])	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

<u>Current</u>

Collector current (d.c.)	I_C	max.	800	mA

<u>Power dissipation</u>

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W

<u>Temperatures</u>

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	190	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2219	2N2219A	
<u>Collector cut-off current</u>					
$I_E = 0$; V_{CB} = 50 V	I_{CBO}	<	10	–	nA
$I_E = 0$; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	–	µA
$I_E = 0$; V_{CB} = 60 V	I_{CBO}	<	–	10	nA
$I_E = 0$; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	–	10	µA
<u>Emitter cut-off current</u>					
$I_C = 0$; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
<u>Currents at reverse biased emitter junction</u>					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

1) Applicable up to I_C = 500 mA

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N2219	2N2219A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55\,°C$	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'} C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

h parameters (common emitter)

I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz		2N2219A			
Input impedance	h_{ie}		2 to	8	kΩ
Reverse voltage transfer ratio	h_{re}	<		8	10^{-4}
Small signal current gain	h_{fe}		50 to	300	
Output admittance	h_{oe}		5 to	35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz					
Input impedance	h_{ie}		0.25 to	1.25	kΩ
Reverse voltage transfer ratio	h_{re}	<		4	10^{-4}
Small signal current gain	h_{fe}		75 to	375	
Output admittance	h_{oe}		25 to	200	$\mu\Omega^{-1}$

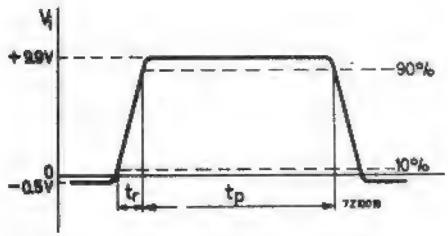
			2N2219	2N2219A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz					
Small signal current gain	h_{fe}	>	2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz					
Real part of input impedance	$Re(h_{ie})$	<	60	60	Ω
Noise figure at f = 1 kHz					
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	<	–	4	dB

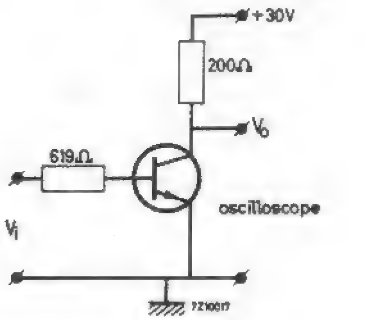
Switching times for 2N2219A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq$ 200 ns
rise time $t_r \leq$ 2 ns

Oscilloscope:
input resistance R_i > 100 kΩ
input capacitance C_i < 12 pF
rise time t_r < 5 ns

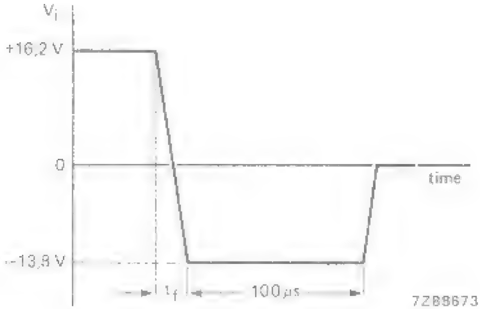
Switching times for 2N2219A

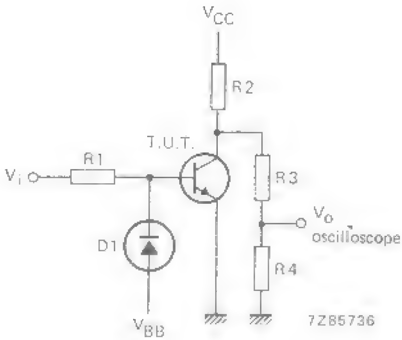
T_j = 25 °C unless otherwise specified

Turn off time
I_C = 150 mA; $I_B = -I_{BM}$ = 15 mA

Storage time	t_s	<	225 ns
Fall time	t_f	<	60 ns

Test circuit:





V_{CC} = + 30 V; V_{BB} = −3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

Pulse generator:

fall time	t_f	<	5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2222 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

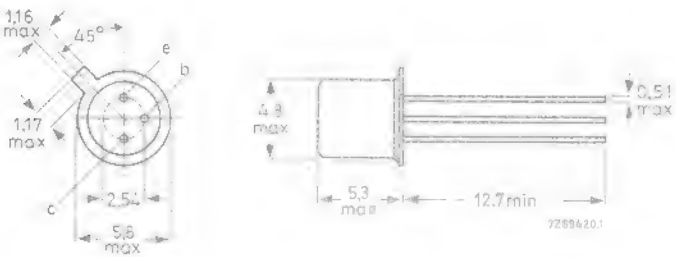
			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz; I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time; I_C = 150 mA; $I_B = -I_{BM}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

Products approved to CECC 50 004-030, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40*	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V
Collector current (d.c.)	I_C	max.	800		mA
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	0,5		W
up to T_{case} = 25 °C	P_{tot}	max.	1,2		W
Storage temperature	T_{stg}		−65 to + 200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	350	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N2222	2N2222A	
Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	10	–	nA
$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	–	μA
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	–	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
$V_{CE} = 60$ V; $-V_{BE} = 3$ V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

* Applicable up to I_C = 500 mA.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N2222	2N2222A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'}C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

h parameters (common emitter)

			2N2222A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}	<	8	10^{-4}
Small signal current	h_{fe}		50 to 300	
Output admittance	h_{oe}		5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}	<	4	10^{-4}
Small signal current gain	h_{fe}		75 to 375	
Output admittance	h_{oe}		25 to 200	$\mu\Omega^{-1}$

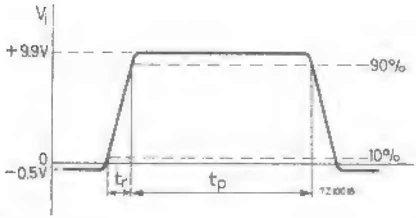
			2N2222	2N2222A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz					
Small signal current gain	h_{fe}	>	2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz					
Real part of input impedance	$Re(h_{ie})$	<	60	60	Ω
Noise figure at f = 1 kHz					
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	<	–	4	dB

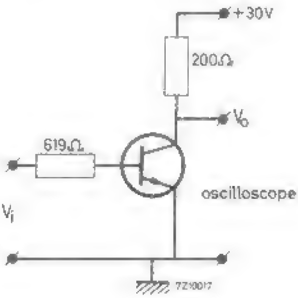
Switching times for 2N2222A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15 mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:			
pulse duration	t_p	≤	200 ns
rise time	t_r	≤	2 ns

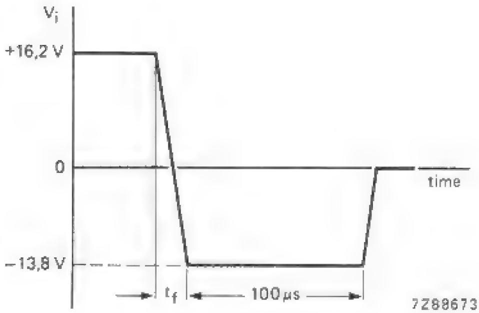
Oscilloscope:			
input resistance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

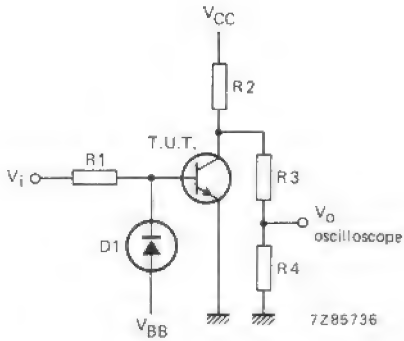
Switching times for 2N2222A — T_j = 25 °C unless otherwise specified

Turn off time
I_C = 150 mA; $I_B = -I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





V_{CC} = + 30 V; V_{BB} = −3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

Pulse generator:

fall time	t_f	<	5	ns

Oscilloscope:

input impedance	R_i	>	100	kΩ
input capacitance	C_i	<	12	pF
rise time	t_r	<	5	ns

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor intended for large signal h.f. and v.h.f. amplifier applications.

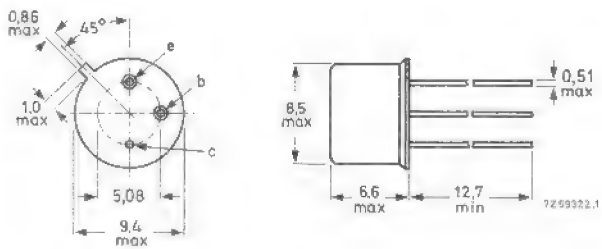
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	80 V
Collector-emitter voltage (open base)	V_{CEO}	max.	35 V
Collector current (d.c.)	I_C	max.	1,0 A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8 W
Junction temperature	T_j	max.	200 °C
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		40 to 120
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	60 MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39; collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	80 V
Collector-emitter voltage (open base)	V_{CEO}	max.	35 V
Emitter-base voltage (open collector)	V_{EBO}	max.	7,0 V
Collector current (d.c.)	I_C	max.	1,0 A
Total power dissipation			
up to T_{case} = 25 °C	P_{tot}	max.	5,0 W
up to T_{case} = 100 °C	P_{tot}	max.	2,8 W
up to T_{amb} = 25 °C	P_{tot}	max.	0,8 W
Storage temperature	T_{stg}		−65 to +200 °C
Junction temperature	T_j	max.	200 °C

THERMAL RESISTANCE

From junction to case	$R_{th\,j\text{-}c}$	=	35 K/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	219 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10 nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5{,}0$ V	I_{EBO}	<	10 nA
Collector-emitter sustaining voltage*			
$I_C = 30$ mA; $I_B = 0$	$V_{CEOsust}$	>	35 V
Saturation voltages*			
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,2 V
$I_C = 1$ A; $I_B = 100$ mA**	V_{CEsat}	<	1,0 V
	V_{BEsat}	<	1,6 V
D.C. current gain*			
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120
$I_C = 1{,}0$ A; $V_{CE} = 10$ V	h_{FE}	>	15
Feedback time constant			
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4,0 MHz	$r_{bb'}C_{b'c}$	<	800 ps
Collector capacitance at f = 500 kHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12 pF
Emitter capacitance at f = 500 kHz			
$I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	<	80 pF
Transition frequency at f = 20 MHz			
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60 MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p = 300\ \mu s$; $\delta \leq 0{,}01$.

** Measured with a lead length of 1 cm.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2368 and 2N2369 are primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

QUICK REFERENCE DATA

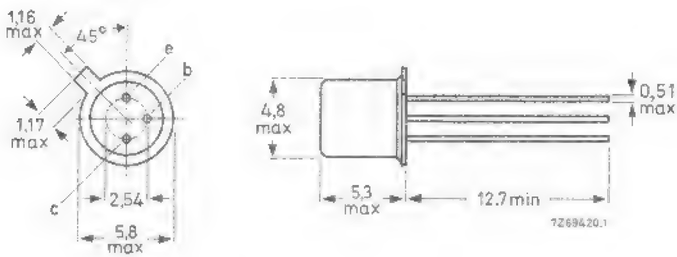
Collector-base voltage (open emitter)		V_{CBO}	max.	40 V
Collector-emitter voltage (open base)		V_{CEO}	max.	15 V
Collector current (peak value)		I_{CM}	max.	500 mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	360 mW
Junction temperature		T_j	max.	200 °C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 1 V	2N2368 2N2369	h_{FE} h_{FE}	20 to 40 to	60 120
Transition frequency I_C = 10 mA; V_{CE} = 10 V	2N2368 2N2369	f_T f_T	> >	400 MHz 500 MHz
Storage time $I_C = I_B = -I_{BM}$ = 10 mA	2N2368 2N2369	t_s t_s	< <	10 ns 13 ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with $V_{BE} = 0$	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; $t = 10\ \mu s$)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.48	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.145	$^oC/mW$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	0,4	μA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	μA
Sustaining voltage*				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V*
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0,25	V
	V_{BEsat}		0,7 to 0,85	V
Collector capacitance at f = 140 kHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF

		2N2368	2N2369	
D.C. current gain*				
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	20 to 60	40 to 120	
$I_C = 10$ mA; $V_{CE} = 1$ V; $T_j = -55$ °C	h_{FE}	> 10	20	
$I_C = 100$ mA; $V_{CE} = 2$ V	h_{FE}	> 10	20	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	> 400	500	MHz

* Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t = 300 μs; duty cycle δ = 0,01.

CHARACTERISTICS (continued)

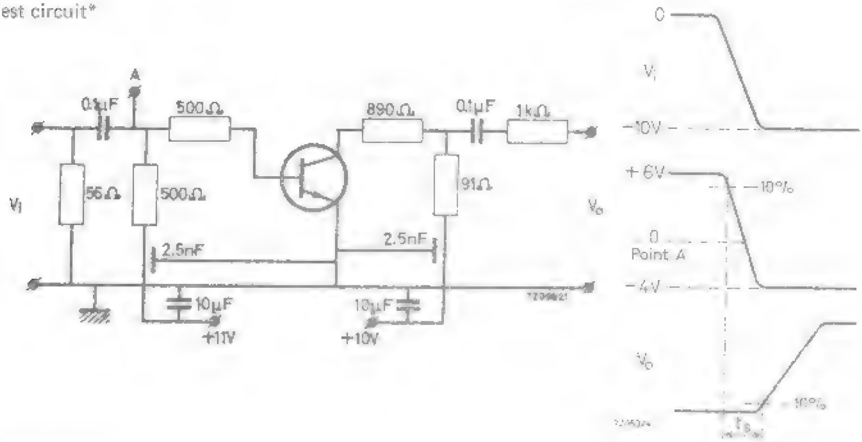
$T_j = 25\ ^oC$

Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N2368	t_s	<	10	ns
2N2369	t_s	<	13	ns

Test circuit*



Turn on time

$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1,5$ V

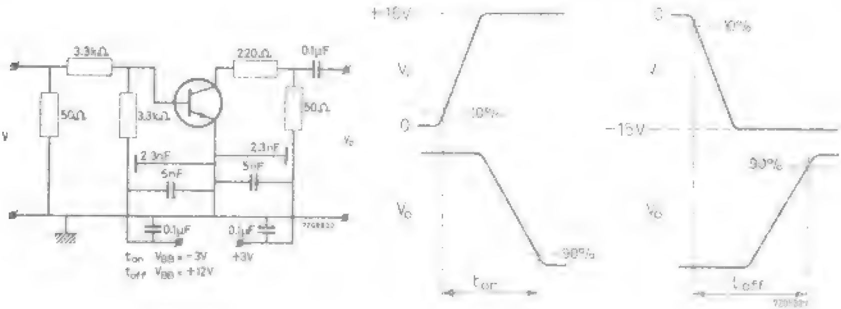
	t_{on}	<	12	ns

Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1,5$ mA

2N2368	t_{off}	<	15	ns
2N2369	t_{off}	<	18	ns

Test circuit*



* Pulse generator

Pulse duration	t	≥	300 ns
Duty cycle	δ	≤	0,02
Rise time	t_r	≤	1 ns
Source impedance	R_S	=	50 Ω

Oscilloscope

Rise time	t_r	≤	1 ns
Input impedance	R_i	=	50 Ω

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope primarily intended for high-speed saturated switching and high frequency amplifier applications.

QUICK REFERENCE DATA

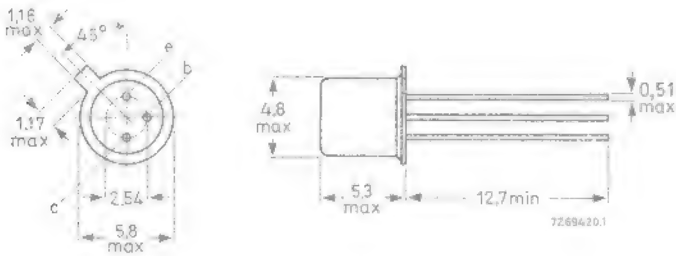
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}	>	40	
I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	<	120	
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
Storage time				
$I_{Con} = I_{Bon} = -I_{Boff}$ = 10 mA	t_s	<	13	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) I_C = 0,01 mA to 10 mA	V_{CEO}	max.	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5	V
Collector current (d.c.)	I_C	max.	200	mA
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
up to T_{case} = 25 °C	P_{tot}	max.	1200	mW
up to T_{case} = 100 °C	P_{tot}	max.	680	mW
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	486	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
V_{BE} = 0; V_{CE} = 20 V	I_{CES}	<	0,4 μA
I_E = 0; V_{CB} = 20 V; T_{amb} = 150 °C	I_{CBO}	<	30 μA
Base current			
V_{BE} = 0; V_{CE} = 20 V	$-I_{BEX}$	<	0,4 μA
Collector-base breakdown voltage			
open emitter; I_C = 10 μA	$V_{(BR)CBO}$	>	40 V
Collector-emitter breakdown voltage			
V_{BE} = 0; I_C = 10 μA	$V_{(BR)CES}$	>	40 V
Emitter-base breakdown voltage			
open collector; I_E = 10 μA	$V_{(BR)EBO}$	>	4,5 V
Collector-emitter sustaining voltage*			
open base; I_C = 10 mA	$V_{CEOsust}$	>	15 V
Saturation voltages			
I_C = 10 mA; I_B = 1,0 mA	V_{CEsat}	<	0,20 V
	V_{BEsat}		0,70 to 0,85 V
I_C = 10 mA; I_B = 1,0 mA; T_{amb} = 125 °C	V_{CEsat}	<	0,30 V
	V_{BEsat}	>	0,59 V
I_C = 10 mA; I_B = 1,0 mA; T_{amb} = −55 °C	V_{BEsat}	<	1,02 V
I_C = 30 mA; I_B = 3,0 mA	V_{CEsat}	<	0,25 V
	V_{BEsat}	<	1,15 V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0,50 V
	V_{BEsat}	<	1,60 V
D.C. current gain*			
I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}	>	40
I_C = 10 mA; V_{CE} = 0,35 V; T_{amb} = −55 °C	h_{FE}	>	20
I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	<	120
I_C = 30 mA; V_{CE} = 0,4 V	h_{FE}	>	30
I_C = 100 mA; V_{CE} = 1,0 V	h_{FE}	>	20
Collector capacitance at f = 140 kHz			
I_E = I_e = 0; V_{CB} = 5,0 V	C_c	<	4,0 pF
Transition frequency at f = 100 MHz			
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500 MHz

* Measured under pulse conditions to avoid excessive dissipation: t_p = 300 μs; $\delta \leqslant$ 0,02.

Storage time (see Figs 2 and 3)
$I_{Con} = I_{Bon} = -I_{Boff} = 10$ mA — t_s < 13 ns

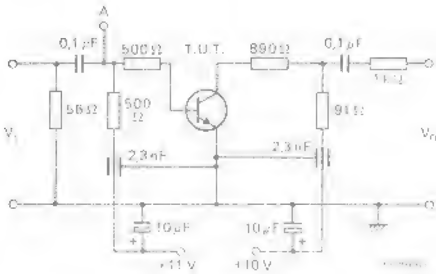


Fig. 2 Storage time test circuit.

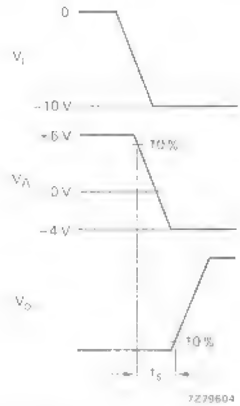


Fig. 3 Waveforms at input, point A and output.

Turn-on time (see Figs 4 and 5)
$I_{Con} = 10$ mA; $I_{Bon} = 3$ mA; $-V_{BEoff} = 1{,}5$ V — t_{on} < 12 ns

Turn-off time (see Figs 4 and 5)
$I_{Con} = 10$ mA; $I_{Bon} = 3$ mA; $-I_{Boff} = 1{,}5$ mA — t_{off} < 18 ns

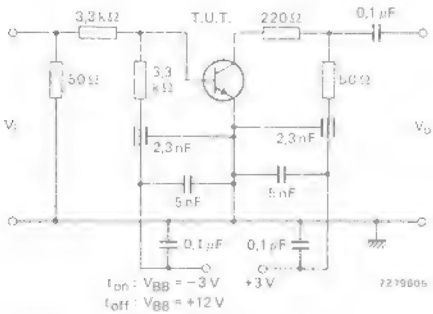


Fig. 4 Turn-on and turn-off test circuit.

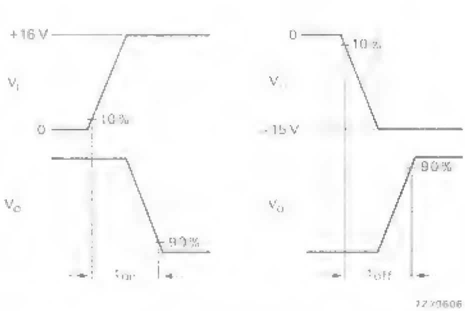


Fig. 5 Input and output waveforms.

Pulse generator:

Rise time	t_r	≤	1 ns
Pulse duration	t_p	≥	300 ns
Duty factor	δ	≤	0,02
Source impedance	R_S	=	50 Ω

Oscilloscope:

Rise time	t_r	≤	1 ns
Input impedance	R_i	=	50 Ω

SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

These transistors are primarily intended for use in high performance, low-level, low-noise amplifier applications both for direct current and frequencies of up to 100 MHz.

QUICK REFERENCE DATA

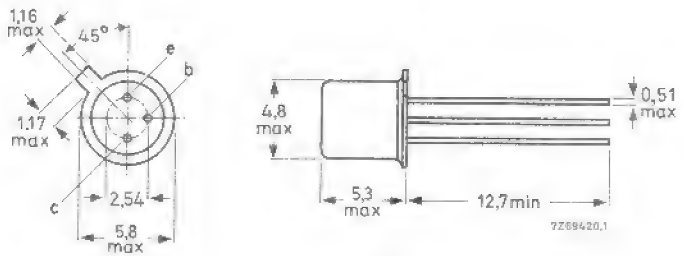
			2N2483	2N2484	
Collector-base voltage (open emitter)	V_{CBO}	max	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	60	V
Collector current (peak value)	I_{CM}	max	50	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	360	360	mW
Junction temperature	T_j	max	200	200	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
		<	120	500	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	>	175	250	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	<	500	800	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ					
I_C = 10 μA; V_{CE} = 5 V; B = 15,7 kHz	F	<	4	3	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V

Currents

Collector current (peak value)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^{o}C$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		−65 to +200	^{o}C
Junction temperature	T_j	max.	200	^{o}C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	$^{o}C/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	$^{o}C/mW$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 45$ V; $T_j = 150$ °C	I_{CBO}	<	10	µA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Base-emitter voltage				
$I_C = 0.1$ mA; $V_{CE} = 5$ V	V_{BE}		0.5 to 0.7	V
Collector-emitter saturation voltage				
$I_C = 1$ mA; $I_B = 0.1$ mA	V_{CEsat}	<	350	mV

D.C. current gain			2N2483	2N2484	
$I_C = 1$ µA; $V_{CE} = 5$ V	h_{FE}	>		30	
$I_C = 10$ µA; $V_{CE} = 5$ V	h_{FE}		40 to 120	100 to 500	
$I_C = 10$ µA; $V_{CE} = 5$ V; $T_j = 55$ °C	h_{FE}	>	10	20	
$I_C = 100$ µA; $V_{CE} = 5$ V	h_{FE}	>	75	175	
$I_C = 500$ µA; $V_{CE} = 5$ V	h_{FE}	>	100	200	
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{FE}	>	175	250	
$I_C = 10$ mA; $V_{CE} = 5$ V [1])	h_{FE}	<	500	800	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	6	6	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	6	6	pF
Transition frequency					
$I_C = 50$ µA; $V_{CE} = 5$ V	f_T	>	12	15	MHz
$I_C = 500$ µA; $V_{CE} = 5$ V	f_T	>	60	60	MHz
		typ.	80	80	MHz

[1]) Measured under pulsed conditions to prevent excessive dissipation.
Pulse duration $t < 300$ µs; duty cycle $\delta < 0.01$

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

		2N2483	2N2484	
Noise figure				
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ				
f = 100 Hz; bandwidth 20 Hz	F	< 15	10	dB
f = 1 kHz; bandwidth 200 Hz	F	< 4	3	dB
f = 10 kHz; bandwidth 2 kHz	F	< 3	2	dB
Wide band: bandwidth 15.7 kHz	F	< 4	3	dB
h parameters at f = 1 kHz				
I_C = 1 mA; V_{CE} = 5 V				
Input impedance	h_{ie}	1.5 to 13	3.5 to 24	kΩ
Reverse voltage transfer	h_{re}	< 8	8	10^{-4}
Small signal current gain	h_{fe}	80 to 450	150 to 900	
Output admittance	h_{oe}	< 30	40	$\mu\Omega^{-1}$

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

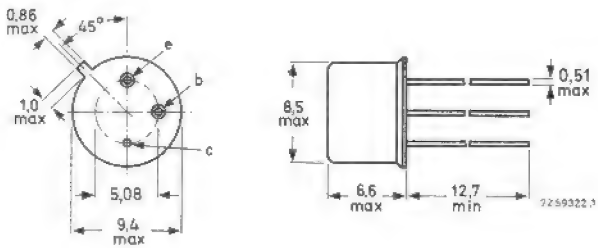
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	2N2904	$-V_{CEO}$	max.	40 V
	2N2904A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6 W
Junction temperature		T_j	max.	200 °C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		40 to 120
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200 MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80 ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-102, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base) $-I_C < 100$ mA	**2N2904**	$-V_{CEO}$	max.	40 V
	2N2904A	$-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25\ ^oC$		P_{tot}	max.	0,6 W
up to $T_{case} = 25\ ^oC$		P_{tot}	max.	3,0 W
Storage temperature		T_{stg}	−65 to +200	^oC
Junction temperature		T_j	max.	200 ^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	292 K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2904	2N2904A	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage *					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages *					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	40	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	25	40	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	40	
$-I_C = 150$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	40	40	
		<	120	120	
$-I_C = 500$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V *	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-on time (see Fig. 2)

when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10 ns
rise time	t_r	<	40 ns
turn-on time	t_{on}	<	45 ns

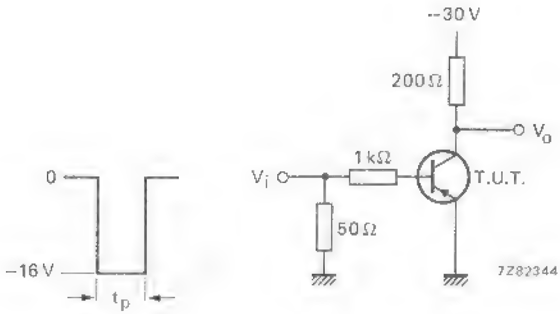


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80 ns
fall time	t_f	<	30 ns
turn-off time	t_{off}	<	100 ns

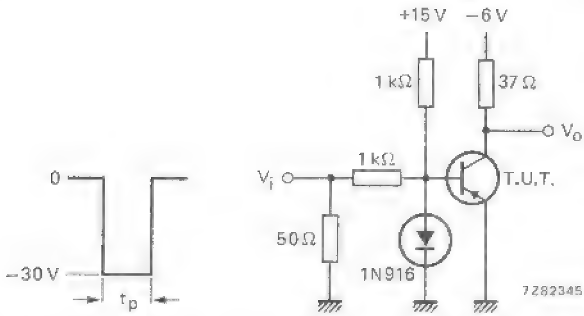


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150 Hz
pulse duration	t_p	=	200 ns
rise time	t_r	≤	2 ns
output impedance	Z_o	=	50 Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	≤	5 ns
input impedance	Z_i	=	10 MΩ

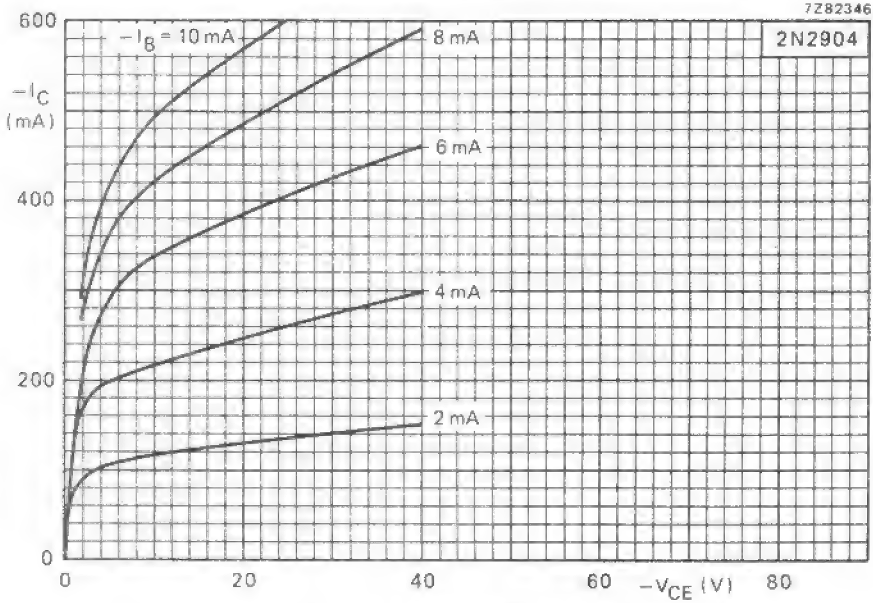


Fig. 4 Typical values; T_j = 25 °C.

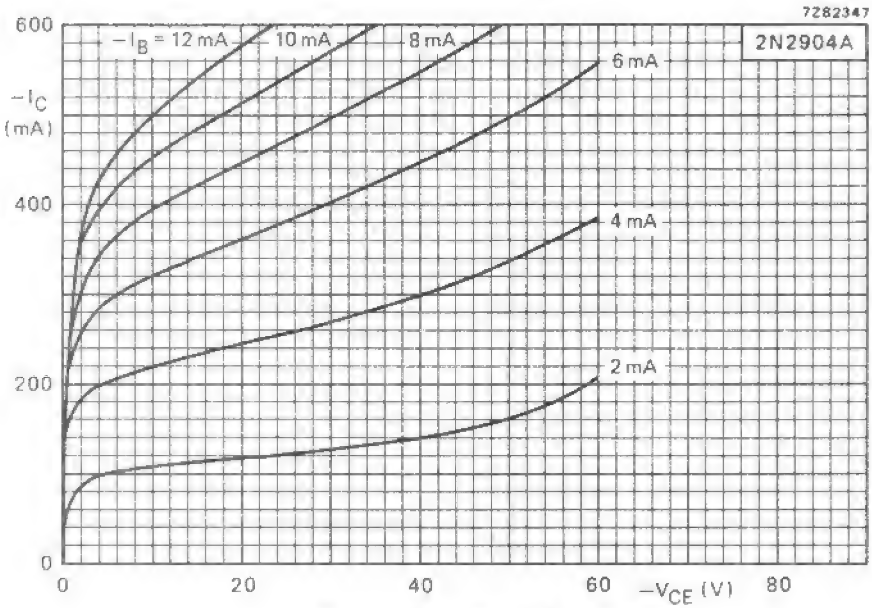


Fig. 5 Typical values; T_j = 25 °C.

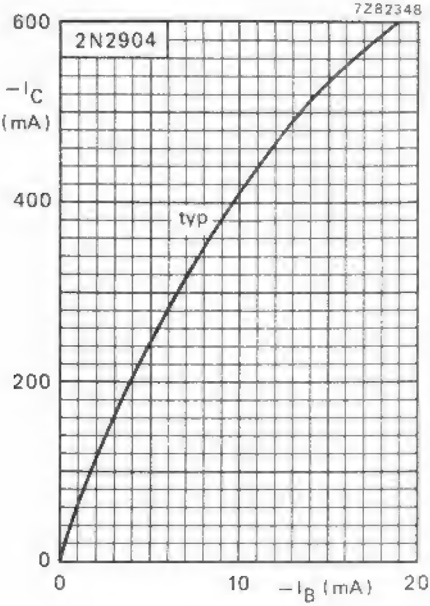


Fig. 6 $-V_{CE}$ = 5,0 V; T_J = 25 °C.

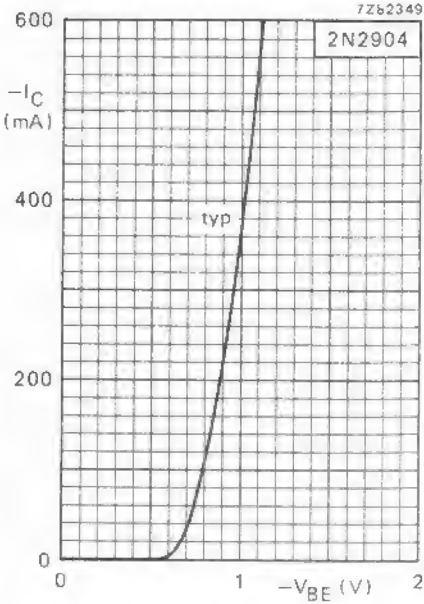


Fig. 7 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

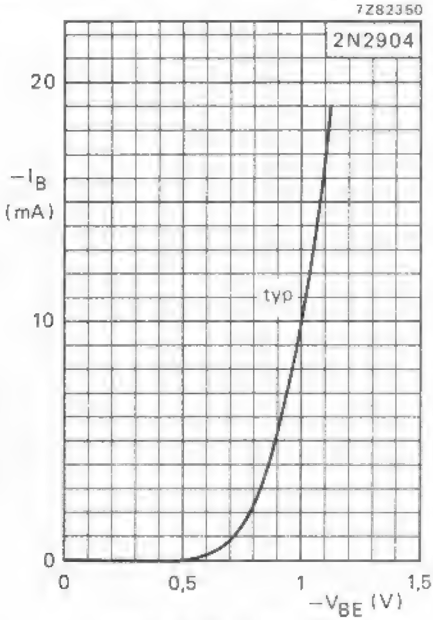


Fig. 8 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

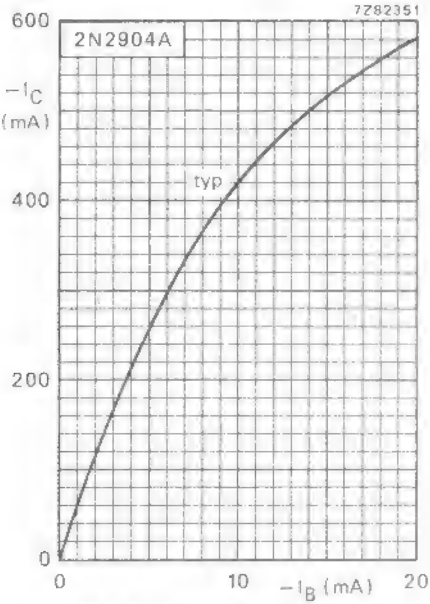


Fig. 9 $-V_{CE} = 5{,}0$ V; $T_j = 25$ °C.

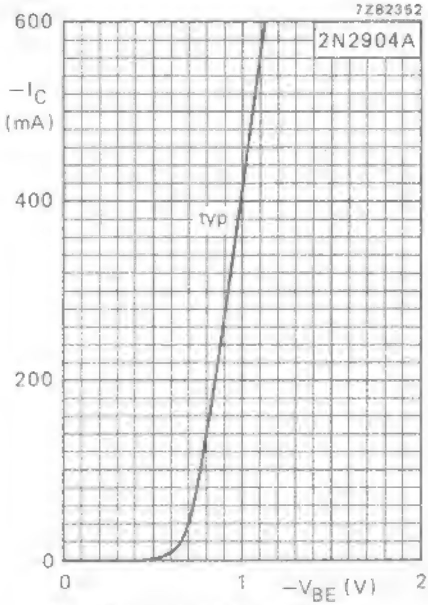


Fig. 10 $-V_{CE} = 5{,}0$ V; $T_j = 25$ °C.

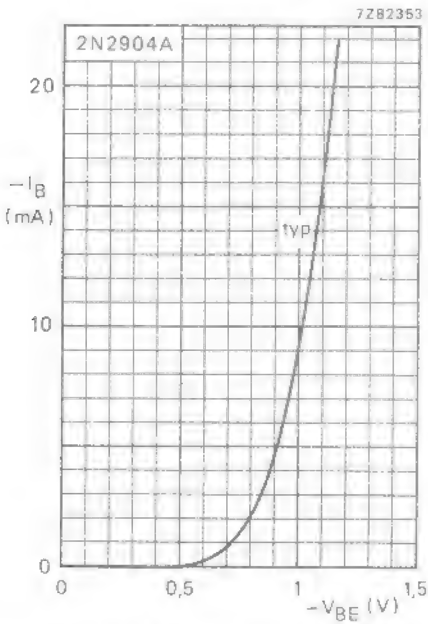


Fig. 11 $-V_{CE} = 5{,}0$ V; $T_j = 25$ °C.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

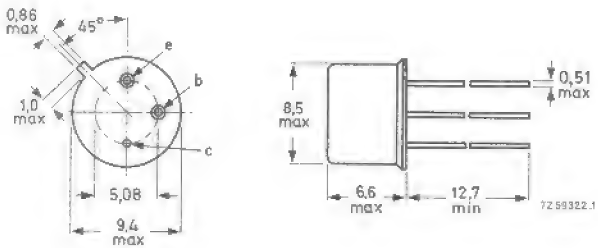
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2905	$-V_{CEO}$	max.	40	V
	2N2905A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}	100 to 300		
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-102, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA	2N2905	$-V_{CEO}$	max.	40	V
	2N2905A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$		P_{tot}	max.	0,6	W
up to $T_{case} = 25\ ^oC$		P_{tot}	max.	3,0	W
Storage temperature		T_{stg}	−65 to + 200		^oC
Junction temperature		T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	292	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2905	2N2905A	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0{,}5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0{,}5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage*					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages*					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0{,}1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100	
$-I_C = 150$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	100	100	
		<	300	300	
$-I_C = 500$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	30	50	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V*	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation; $t_p \leq 300$ μs; $\delta \leq 0{,}02$.

Turn-on time (see Fig. 2)

when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

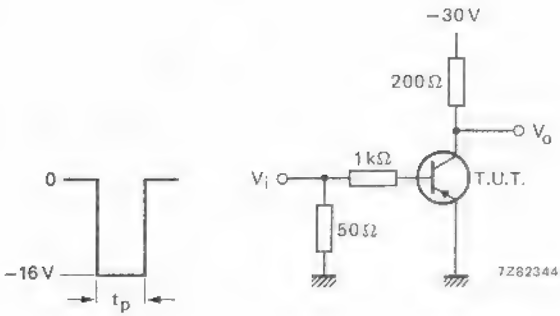


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

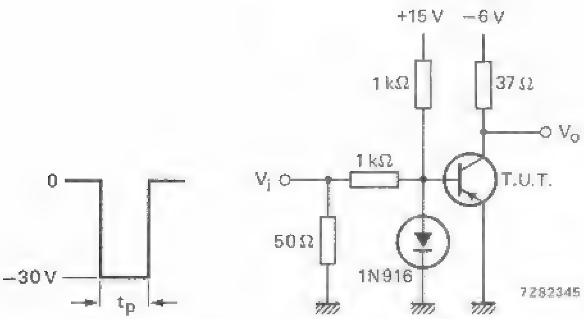


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150 Hz
pulse duration	t_p	=	200 ns
rise time	t_r	≤	2 ns
output impedance	Z_o	=	50 Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	≤	5 ns
input impedance	Z_i	=	10 MΩ

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P medium power transistors in TO-18 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

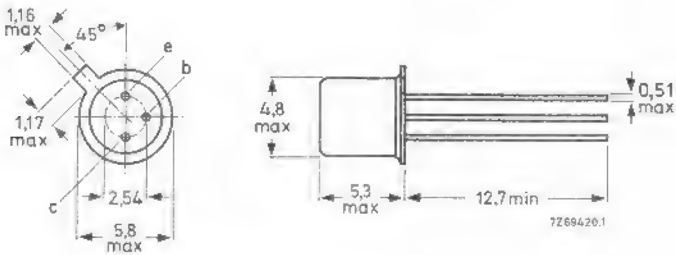
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2906	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		40 to 120	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-103, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA	2N2906	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$		P_{tot}	max.	0,4	W
up to $T_{case} = 25\ ^oC$		P_{tot}	max.	1,2	W
Storage temperature		T_{stg}	−65 to + 200		^oC
Junction temperature		T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	438	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2906	2N2906A	
Collector cut-off current					
I_E = 0; $-V_{CB}$ = 50 V	$-I_{CBO}$	<	20	10	nA
I_E = 0; $-V_{CB}$ = 50 V; T_{amb} = 150 °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE}$ = 0,5 V; $-V_{CE}$ = 30 V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE}$ = 0,5 V; $-V_{CE}$ = 30 V	I_{BEX}	<	50	50	nA
Collector-base breakdown voltage					
open emitter; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage*					
open base; $-I_C$ = 10 mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages*					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C$ = 0,1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40	
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	25	40	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40	
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V*	h_{FE}	>	40	40	
		<	120	120	
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V*	h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz					
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c$ = 0; $-V_{EB}$ = 2 V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V*	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leq 300\ \mu s$; $\delta \leq 0{,}02$.

Turn-on time (see Fig. 2)

when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

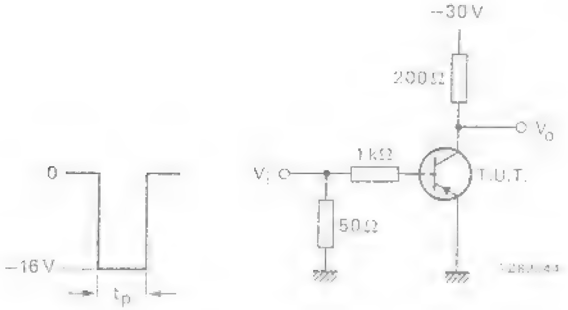


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

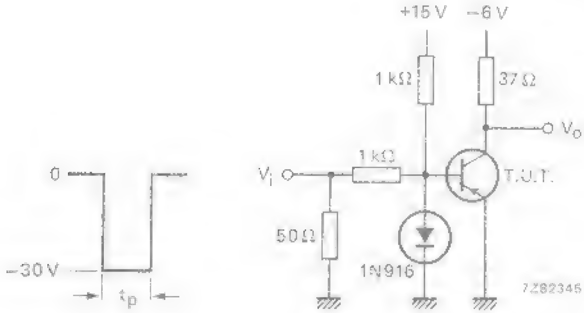


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150	Hz
pulse duration	t_p	=	200	ns
rise time	t_r	≤	2	ns
output impedance	Z_o	=	50	Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	≤	5	ns
input impedance	Z_i	≤	10	MΩ

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P medium power transistors in TO-18 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

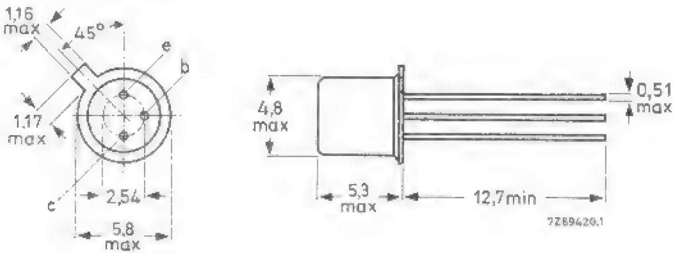
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2907	$-V_{CEO}$	max.	40	V
	2N2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		100 to 300	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-103, available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)				
$-I_C < 100$ mA	2N2907	$-V_{CEO}$	max.	40 V
	2N2907A	$-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation				
up to $T_{amb} = 25\ ^{o}C$		P_{tot}	max.	0,4 W
up to $T_{case} = 25\ ^{o}C$		P_{tot}	max.	1,2 W
Storage temperature		T_{stg}	−65 to	+200 ^{o}C
Junction temperature		T_j	max.	200 ^{o}C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	438 K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146 K/W

CHARACTERISTICS

$T_{amb} = 25\ ^oC$ unless otherwise specified

			2N2907	2N2907A
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10 nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150\ ^oC$	$-I_{CBO}$	<	20	10 μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50 nA
Base current				
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50 nA
Collector-base breakdown voltage				
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60 V
Collector-emitter breakdown voltage *				
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60 V
Emitter-base breakdown voltage				
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5 V
Saturation voltages *				
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4 V
	$-V_{BEsat}$	<	1,3	1,3 V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6 V
	$-V_{BEsat}$	<	2,6	2,6 V
D.C. current gain				
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100
$-I_C = 150$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	100	100
		<	300	300
$-I_C = 500$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	30	50
Collector capacitance at f = 100 kHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8	pF
Emitter capacitance at f = 100 kHz				
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30	pF
Transition frequency at f = 100 MHz				
$-I_C = 50$ mA; $-V_{CE} = 20$ V *	f_T	>	200	MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-on time (see Fig. 2)
when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

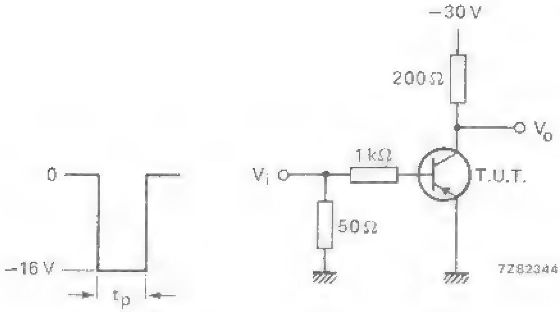


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)
when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

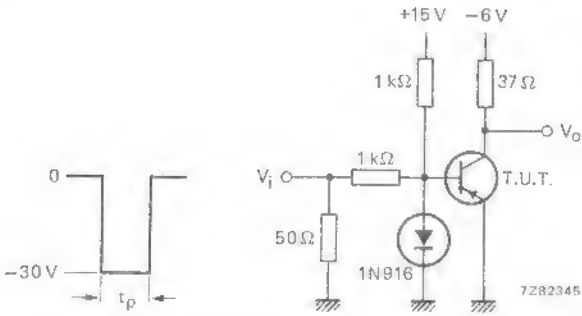


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150	Hz
pulse duration	t_p	=	200	ns
rise time	t_r	≤	2	ns
output impedance	Z_o	=	50	Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	≤	5	ns
input impedance	Z_i	≤	10	MΩ

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes intended for use as amplifiers and in switching circuits.

QUICK REFERENCE DATA

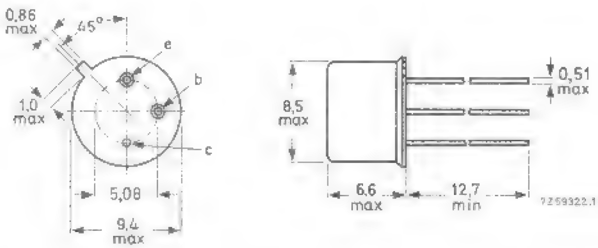
Collector-base voltage (open emitter)	V_{CBO}	max.	140		V
Collector-emitter voltage (open base)	V_{CEO}	max.	80		V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
			2N3019	2N3020	
D.C. current gain					
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	
		<	300	120	
Transition frequency at f = 20 MHz					
I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	80	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-175, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Current

Collector current (d.c.)	I_C	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	5,0	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	218	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA

Breakdown voltages

$I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	>	140	V
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	80	V [1]
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7	V

Saturation voltages

$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,2	V
	V_{BEsat}	<	1,1	V [1]
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5	V [1]

[1]) Measured under pulse conditions: $t_p = 300$ μs; $\delta \leq 0,01$.

CHARACTERISTICS (continued) $T_{amb} = 25\ ^oC$ unless otherwise specified

			2N3019	2N3020	
D.C. current gain [1]					
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	50	30	
		<	–	100	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	90	40	
		<	–	120	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	
		<	300	120	
I_C = 150 mA; V_{CE} = 10 V; T_{case} = −55 °C	h_{FE}	>	40	–	
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>	50	30	
		<	–	100	
I_C = 1000 mA; V_{CE} = 10 V	h_{FE}	>	15	15	
Transition frequency at f = 20 MHz					
I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	80	MHz
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	<	12	12	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	<	60	60	pF
Feedback time constant at f = 4 MHz					
I_C = 10 mA; V_{CB} = 10 V	$r_{bb'}C_{b'c}$	<	400	400	ps
Small-signal current gain at f = 1 kHz					
I_C = 1,0 mA; V_{CE} = 5 V	h_{fe}	>	80	30	
		<	400	200	
Noise figure at f = 1 kHz					
I_C = 0,1 mA; V_{CE} = 10 V; R_S = 1 kΩ	F	<	4	–	dB

[1] Measured under pulse conditions ; t_p = 300 μs; δ ≤ 0,01.

SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-39 metal envelope designed for medium speed, saturated and non-saturated switching applications for industrial service.

QUICK REFERENCE DATA

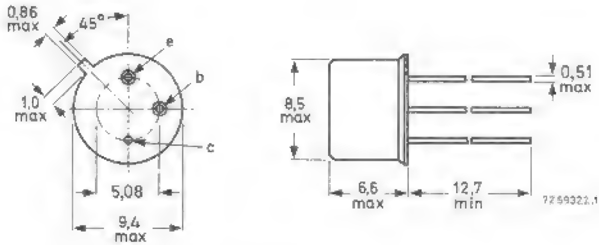
Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (d.c.)	I_C	max.	700	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		50 to 250	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.
Accessories: 56245 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	60 V
Collector-emitter voltage (open base)*	V_{CEO}	max.	40 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	700 mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0 W
Storage temperature	T_{stg}	–65 to + 200 °C	
Junction temperature	T_j	max.	200 °C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	35 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current V_{CE} = 30 V; $-V_{BE}$ = 1,5 V	I_{CEX}	<	0,25 µA
Emitter cut-off current I_C = 0; V_{EB} = 4 V	I_{EBO}	<	0,25 µA
Collector-base breakdown voltage open emitter; I_C = 100 µA	$V_{(BR)CBO}$	>	60 V
Collector-emitter breakdown voltage** open emitter; I_C = 100 µA	$V_{(BR)CEO}$	>	40 V
I_C = 100 mA; R_{BE} = 10 Ω	$V_{(BR)CER}$	>	50 V
Emitter-base breakdown voltage open collector; I_E = 100 µA	$V_{(BR)EBO}$	>	5 V
Base-emitter voltage I_C = 150 mA; V_{CE} = 2,5 V	V_{BE}	<	1,7 V
Saturation voltages I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	1,4 V
	V_{BEsat}	<	1,7 V
D.C. current gain I_C = 150 mA; V_{CE} = 2,5 V	h_{FE}	>	25
I_C = 150 mA; V_{CE} = 10 V**	h_{FE}		50 to 250
Collector capacitance at f = 140 kHz $I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	15 pF
Emitter capacitance at f = 140 kHz $I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	80 pF
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	100 MHz

* For I_C = 0 to 100 mA (pulse conditions): t_p = 300 µs; δ = 0,018, 0 to 700 mA for shorter pulses.
** Measured under pulse conditions to avoid excessive dissipation: t_p = 300 µs; δ = 0,018.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

P-N-P complements are 2N3905 and 2N3906.

QUICK REFERENCE DATA

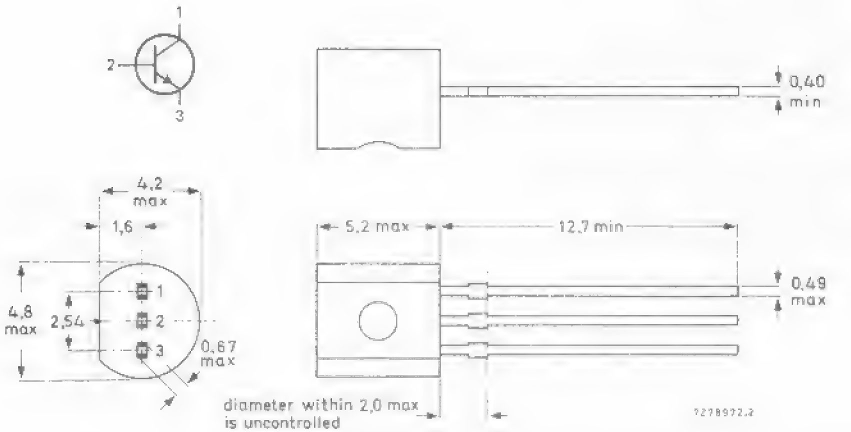
Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (d.c.)	I_C	max.	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	mW
Junction temperature	T_j	max.	150	°C

			2N3903	2N3904	
D.C. current gain I_C = 10 mA; V_{CE} = 1 V	h_{FE}	> <	50 150	100 300	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_{Con} = 10 mA; I_{Bon} = $-I_{Boff}$ = 1 mA	t_s	<	175	200	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	60 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40 V
Emitter-base voltage (open collector)	V_{EBO}	max.	6 V
Collector current (d.c.)	I_C	max.	200 mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350 mW
→ Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	357 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Currents at reverse biased emitter junction V_{CE} = 30 V; $-V_{BE}$ = 3 V	I_{CEX}	<	50 nA
	$-I_{BEX}$	<	50 nA
Saturation voltages * I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	200 mV
	V_{BEsat}		650 to 850 mV
I_C = 50 mA; I_B = 5 mA	V_{CEsat}	<	300 mV
	V_{BEsat}	<	950 mV

			2N3903	2N3904	
D.C. current gain * I_C = 0,1 mA; V_{CE} = 1 V	h_{FE}	>	20	40	
I_C = 1 mA; V_{CE} = 1 V	h_{FE}	>	35	70	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	50	100	
		<	150	300	
I_C = 50 mA; V_{CE} = 1 V	h_{FE}	>	30	60	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	15	30	
Collector capacitance at 100 kHz ⩽ f ⩽ 1 MHz $I_E = I_e$ = 0; V_{CB} = 5 V	C_c	<	4	4	pF
Emitter capacitance at 100 kHz ⩽ f ⩽ 1 MHz $I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	8	8	pF
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Noise figure at R_S = 1 kΩ I_C = 100 μA; V_{CE} = 5 V f = 10 Hz to 15,7 kHz	F	<	6	5	dB

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

h-parameters (common emitter)
$I_C = 1$ mA; $V_{CE} = 10$ V; f = 1 kHz

		2N3903	2N3904	
Input impedance	h_{ie}	1 to 8	1 to 10	kΩ
Reverse voltage transfer ratio	h_{re}	0,1 to 5	0,5 to 8	10^{-4}
Small-signal current gain	h_{fe}	50 to 200	100 to 400	
Output admittance	h_{oe}	1 to 40	1 to 40	μA/V

Switching times
Turn-on time (see Figs 2 and 3) when switched from
$-V_{BEoff} = 0,5$ V to $I_{Con} = 10$ mA; $I_{Bon} = 1$ mA

		2N3903	2N3904	
Delay time	t_d	< 35	35	ns
Rise time	t_r	< 35	35	ns

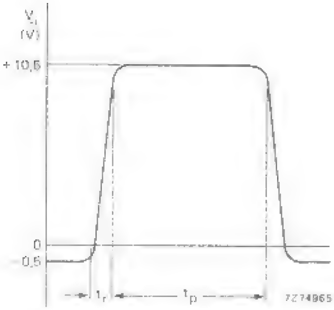


Fig. 2 Input waveform; $t_r < 1$ ns; $t_p = 300$ ns; $\delta = 0,02$.

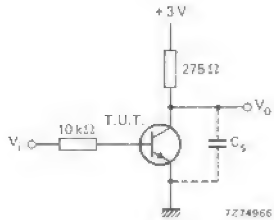


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

Turn-off time (see Figs 4 and 5)
$I_{Con} = 10$ mA; $I_{Bon} = -I_{Boff} = 1$ mA

		2N3903	2N3904	
Storage time	t_s	< 175	200	ns
Fall time	t_f	< 50	50	ns

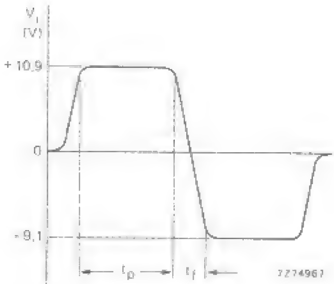


Fig. 4 Input waveform; $t_f < 1$ ns; $10\ \mu s < t_p < 500\ \mu s$; $\delta = 0,02$.

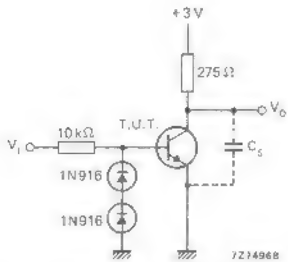


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

N-P-N complements are 2N3903 and 2N3904.

QUICK REFERENCE DATA

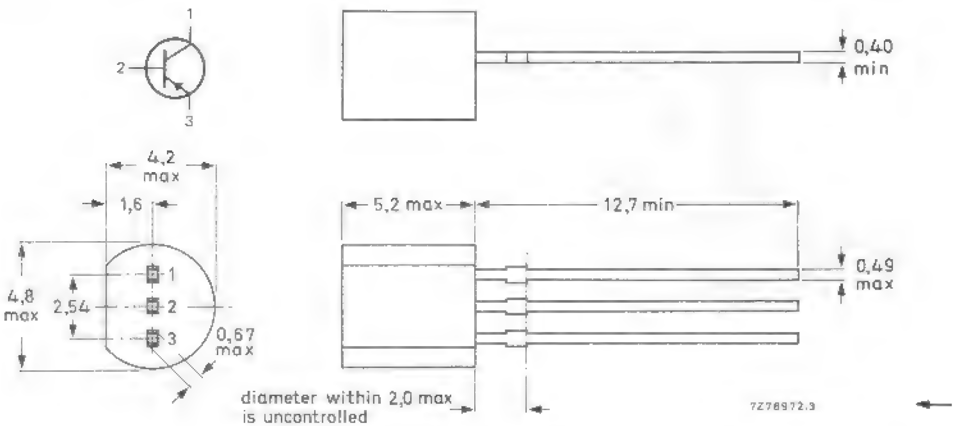
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	V
Collector current (d.c.)	$-I_C$	max.	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	mW
Junction temperature	T_j	max.	150	°C

			2N3905	2N3906	
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	50	100	
		<	150	300	
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250	MHz
Storage time $-I_{Con}$ = 10 mA; $-I_{Bon}$ = I_{Boff} = 1 mA	t_s	<	200	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	200 mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350 mW
Storage temperature	T_{stg}		–65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	357 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Currents at reverse biased emitter junction $-V_{CE}$ = 30 V; + V_{BE} = 3 V	$-I_{CEX}$	<	50 nA
	$+I_{BEX}$	<	50 nA
Saturation voltages * $-I_C$ = 10 mA; $-I_B$ = 1 mA	$-V_{CEsat}$	<	250 mV
	$-V_{BEsat}$		650 to 850 mV
$-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	<	400 mV
	$-V_{BEsat}$	<	950 mV

			2N3905	2N3906
D.C. current gain *				
$-I_C$ = 0,1 mA; V_{CE} = 1 V	h_{FE}	>	30	60
$-I_C$ = 1 mA; V_{CE} = 1 V	h_{FE}	>	40	80
$-I_C$ = 10 mA; V_{CE} = 1 V	h_{FE}	>	50	100
		<	150	300
$-I_C$ = 50 mA; V_{CE} = 1 V	h_{FE}	>	30	60
$-I_C$ = 100 mA; V_{CE} = 1 V	h_{FE}	>	15	30
Collector capacitance at 100 kHz ⩽ f ⩽ 1 MHz $I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	<	4,5	4,5 pF
Emitter capacitance at 100 kHz ⩽ f ⩽ 1 MHz $I_C = I_c$ = 0; $-V_{EB}$ = 0,5 V	C_e	<	10	10 pF
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250 MHz
Noise figure at R_S = 1 kΩ $-I_C$ = 100 μA; $-V_{CE}$ = 5 V f = 10 Hz to 15,7 kHz	F	<	5	4 dB

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

h-parameters (common emitter)
$-I_C = 1$ mA; $-V_{CE} = 10$ V; f = 1 kHz

		2N3905	2N3906	
Input impedance	h_{ie}	0,5 to 8	2 to 12	kΩ
Reverse voltage transfer ratio	h_{re}	0,1 to 5	0,1 to 10	10^{-4}
Small-signal current gain	h_{fe}	50 to 200	100 to 400	
Output admittance	h_{oe}	1 to 40	3 to 60	μA/V

Switching times

Turn-on time (see Figs 2 and 3) when switched from
$+V_{BEoff} = 0,5$ V to $-I_{Con} = 10$ mA; $-I_{Bon} = 1$ mA

			2N3905	2N3906	
Delay time	t_d	<	35	35	ns
Rise time	t_r	<	35	35	ns

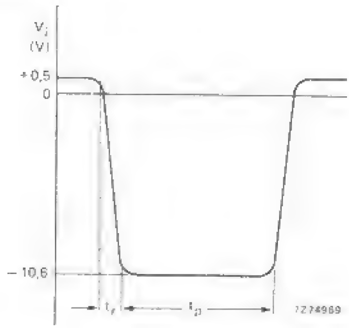


Fig. 2 Input waveform; $t_r < 1$ ns; $t_p = 300$ ns; $\delta = 0,02$.

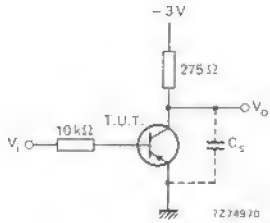


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

Turn-off time (see Figs 4 and 5)
$-I_{Con} = 10$ mA; $-I_{Bon} = I_{Boff} = 1$ mA

			2N3905	2N3906	
Storage time	t_s	<	200	225	ns
Fall time	t_f	<	60	75	ns

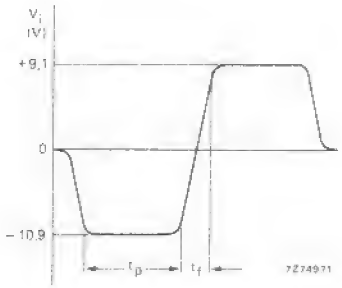


Fig. 4 Input waveform; $t_f < 1$ ns; $10\ \mu s < t_p < 500\ \mu s$; $\delta = 0,02$.

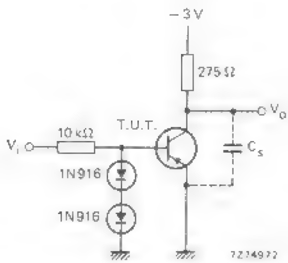


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes primarily intended for large signal, low-noise, low-power audio frequency applications for industrial service.

QUICK REFERENCE DATA

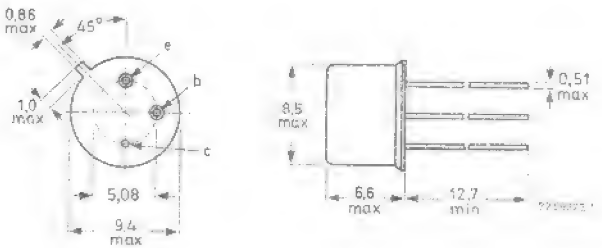
			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
Junction temperature	T_j	max.	200		°C
			2N4030 2N4031	2N4032 2N4033	
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 5 V	h_{FE}	>	25	70	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 002-131, available on request.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current				
Collector current (d.c.)	$-I_C$	max.	1	A
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	4,0	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	218	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	44	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

			2N4030 2N4032	2N4031 2N4033		
Collector cut-off current						
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	50	–	nA	
$I_E = 0$; $-V_{CB} = 60$ V	$-I_{CBO}$	<	–	50	nA	
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	50	–	µA	
$I_E = 0$; $-V_{CB} = 60$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	–	50	µA	
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	10	µA	
Breakdown voltages						
$I_E = 0$; $-I_C = 10$ µA	$-V_{(BR)CBO}$	>	60	80	V	
$I_B = 0$; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	60	80	V	1)
$I_C = 0$; $-I_E = 10$ µA	$-V_{(BR)EBO}$	>	5	5	V	

1) Measured under pulse conditions: $t_p = 300$ µs; $\delta \leq 0,01$.

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

			2N4030 2N4032	2N4031 2N4033	
Base-emitter voltage					
$-I_C$ = 500 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	<	1,1	1,1	V [1]
$-I_C$ = 1000 mA; $-V_{CE}$ = 1,0 V	$-V_{BE}$	<	1,2	–	V [1]
Saturation voltages					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0,15	0,15	V
	$-V_{BEsat}$	<	0,90	0,90	V [1]
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,50	0,50	V
$-I_C$ = 1000 mA; $-I_B$ = 100 mA	$-V_{CEsat}$	<	1,00	–	V

			2N4030 2N4031	2N4032 2N4033
D.C. current gain [1]				
$-I_C$ = 100 µA ; $-V_{CE}$ = 5 V	h_{FE}	>	30	75
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V	h_{FE}	>	40	100
		<	120	300
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V; T_{amb} = −55 °C	h_{FE}	>	15	40
$-I_C$ = 500 mA; $-V_{CE}$ = 5 V	h_{FE}	>	25	70

$-I_C$ = 1000 mA; $-V_{CE}$ = 5 V	2N4030	h_{FE}	>	15	
	2N4031	h_{FE}	>	10	
	2N4032	h_{FE}	>	40	
	2N4033	h_{FE}	>	25	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB}$ = 10 V		C_c	<	20	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V		C_e	<	110	pF

			2N4030 2N4031	2N4032 2N4033	
Transition frequency at f = 100 MHz					
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	MHz
		<	400	500	MHz

[1] Measured under pulse conditions: t_p = 300 µs; $\delta \le 0,01$.

CHARACTERISTICS (continued) $T_{amb} = 25\ ^{o}C$

Switching times [1]

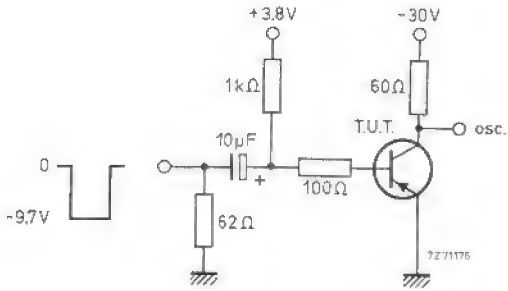
$-I_{Con} = 500$ mA; $-I_{Bon} = 50$ mA

Turn-on time	t_{on}	<	100	ns

$-I_{Con} = 500$ mA; $-I_{Bon} = +I_{Boff} = 50$ mA

Storage time	t_s	<	350	ns
Fall time	t_f	<	50	ns

Switching circuit:



Pulse generator:

Rise time	t_r < 20 ns
Fall time	t_f < 20 ns
Pulse duration	t_p = 10 μs
Duty factor	δ < 0,02
Source impedance	Z_S = 50 Ω

Oscilloscope:

Rise time	t_r = 10 ns
Input impedance	Z_I > 100 kΩ

[1]) See switching circuit for exact values of I_{Con}; I_{Bon} and I_{Boff}.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

P-N-P complements are 2N4125 and 2N4126.

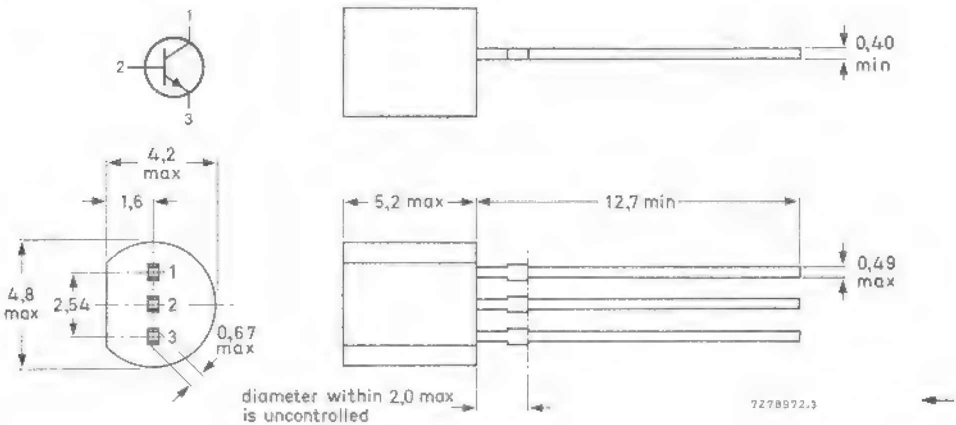
QUICK REFERENCE DATA

			2N4123	2N4124	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	25	V
Collector current (d.c.)	I_C	max.	200	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	350	mW
Junction temperature	T_j	max.	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	> <	50 200	120 480	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Noise figure at R_S = 1 kΩ I_C = 100 µA; V_{CE} = 5 V f = 10 Hz to 15,7 kHz	F	<	6	5	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N4123	2N4124	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5		V
Collector current (d.c.)	I_C	max.	200		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350		mW
Total power dissipation at T_{case} = 25 °C	P_{tot}	max.	1000		mW
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	357	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	125	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; V_{CB} = 20 V	I_{CBO}	<	50	nA
Emitter cut-off current $I_C = 0$; V_{EB} = 3 V	I_{EBO}	<	50	nA
Saturation voltages * I_C = 50 mA; I_B = 5 mA	V_{CEsat}	<	300	mV
	V_{BEsat}	<	950	mV

			2N4123	2N4124	
D.C. current gain * I_C = 2 mA; V_{CE} = 1 V	h_{FE}	>	50	120	
		<	150	360	
I_C = 50 mA; V_{CE} = 1 V	h_{FE}	>	25	60	
Collector capacitance at f = 100 kHz $I_E = I_e = 0$; V_{CB} = 5 V	C_c	<	4	4	pF
Emitter capacitance at f = 100 kHz $I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	<	8	8	pF
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Noise figure at R_S = 1 kΩ I_C = 100 μA; V_{CE} = 5 V f = 10 Hz to 15,7 kHz	F	<	6	5	dB
Small-signal current gain I_C = 2 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	>	50	120	
		<	200	480	

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

N-P-N complements are 2N4123 and 2N4124.

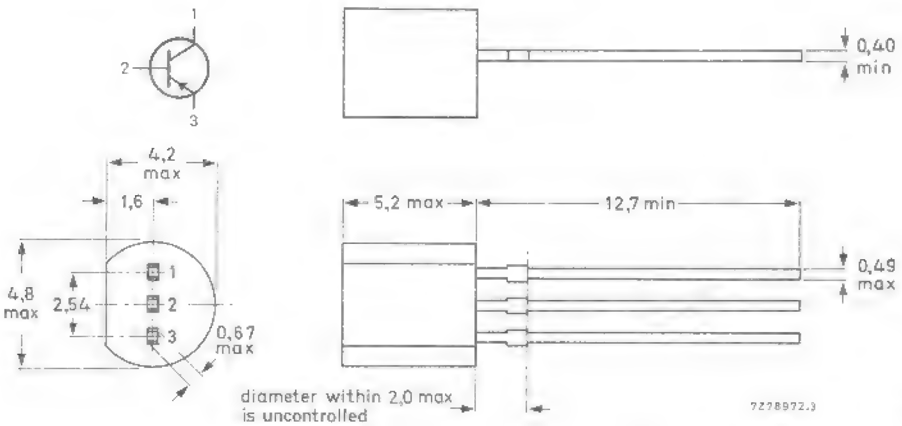
QUICK REFERENCE DATA

			2N4125	2N4126	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	25	V
Collector current (d.c.)	$-I_C$	max.	200	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	350	mW
Junction temperature	T_j	max.	150	150	°C
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 10 V; f = 1 kHz	h_{fe}	> <	50 200	120 480	
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250	MHz
Noise figure at R_S = 1 kΩ $-I_C$ = 100 μA; $-V_{CE}$ = 5 V f = 10 Hz to 15,7 kHz	F	<	5	4	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N4125	2N4126	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4		V
Collector current (d.c.)	$-I_C$	max.	200		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350		mW
Total power dissipation at T_{case} = 25 °C	P_{tot}	max.	1000		mW
→ Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	357	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	125	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current $I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	50	nA
Saturation voltages * $-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	400	mV
	$-V_{BEsat}$	<	950	mV

			2N4125	2N4126	
D.C. current gain * $-I_C = 2$ mA; $-V_{CE} = 1$ V	h_{FE}	> <	50 150	120 360	
$-I_C = 50$ mA; $-V_{CE} = 1$ V	h_{FE}	>	25	60	
Collector capacitance at f = 100 kHz $I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	<	4,5	4,5	pF
Emitter capacitance at f = 100 kHz $I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	<	10	10	pF
Transition frequency at f = 100 MHz $-I_C = 10$ mA; $-V_{CE} = 20$ V	f_T	>	200	250	MHz
Noise figure at $R_S = 1$ kΩ $-I_C = 100$ μA; $-V_{CE} = 5$ V f = 10 Hz to 15,7 kHz	F	<	5	4	dB
Small-signal current gain $-I_C = 2$ mA; $-V_{CE} = 10$ V; f = 1 kHz	h_{fe}	> <	50 200	120 480	

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

P-N-P high-voltage small-signal transistors for general purposes and especially in telephony applications and encapsulated in a TO-92 envelope.

N-P-N complements are 2N 5550 and 2N5551.

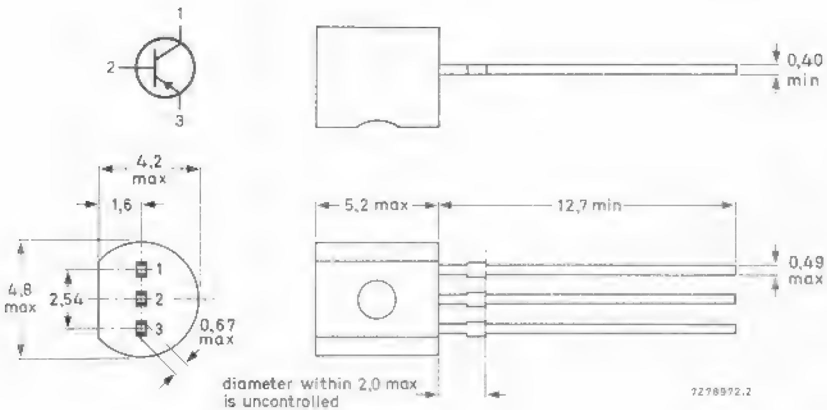
QUICK REFERENCE DATA

			2N5400	2N5401	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	130	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	120	150	V
Collector current	$-I_C$	max.	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,5	0,5	V
D.C. current gain I_C = 10 mA; V_{CE} = −5 V	h_{FE}	min.	40	60	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N5400	2N5401	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	130	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	120	150	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current	$-I_C$	max.	600		mA
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
up to T_{case} = 25 °C	P_{tot}	max.	1000		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−65 to + 150		°C

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N5400	2N5401	
Collector cut-off current					
$I_E = 0$; $-V_{CB}$ = 100 V	$-I_{CBO}$	max.	100		nA
$I_E = 0$; $-V_{CB}$ = 120 V	$-I_{CBO}$	max.		50	nA
$I_E = 0$; $-V_{CB}$ = 100 V; T_{amb} = 100 °C	$-I_{CBO}$	max.	100		µA
$I_E = 0$; $-V_{CB}$ = 120 V; T_{amb} = 100 °C	$-I_{CBO}$	max.		50	µA
Emitter cut-off current					
$I_C = 0$; $-V_{EB}$ = 4,0 V	$-I_{EBO}$	max.	50	50	nA
Breakdown voltages					
I_C = 1,0 mA; $I_B = 0$	$-V_{(BR)CEO}$	min.	120	150	V
I_C = 100 µA; $I_E = 0$	$-V_{(BR)CBO}$	min.	130	160	V
$I_C = 0$; I_E = 10 µA	$-V_{(BR)EBO}$	min.	5,0	5,0	V
Saturation voltages					
$-I_C$ = 10 mA; $-I_B$ = 1,0 mA	$-V_{CEsat}$	max.	0,2	0,2	V
	$-V_{BEsat}$	max.	1,0	1,0	V
$-I_C$ = 50 mA; $-I_B$ = 5,0 mA	$-V_{CEsat}$	max.	0,5	0,5	V
	$-V_{BEsat}$	max.	1,0	1,0	V
D.C. current gain					
I_C = 1,0 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	30	50	
I_C = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	40	60	
		max.	180	240	
I_C = 50 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	40	50	
Small-signal current gain					
I_C = 1,0 mA; $-V_{CE}$ = 10 V; f = 1 kHz	h_{fe}	min.	30	40	
		max.	200	200	
Output capacitance at f = 1 MHz					
$I_E = 0$; $-V_{CB}$ = 10 V	C_o	max.	6	6	pF
Transition frequency at f = 100 MHz					
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	min.	100	100	MHz
		max.	400	300	MHz
Noise figure at R_S = 1 kΩ					
I_C = 250 µA; $-V_{CE}$ = 5 V; f = 10 Hz to 15,7 kHz	F	max.	8	8	dB

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Transistors in TO-39 metal envelopes with the collector connected to the case. They are intended for high-speed switching and linear amplifier applications in military, industrial and commercial equipment.

QUICK REFERENCE DATA

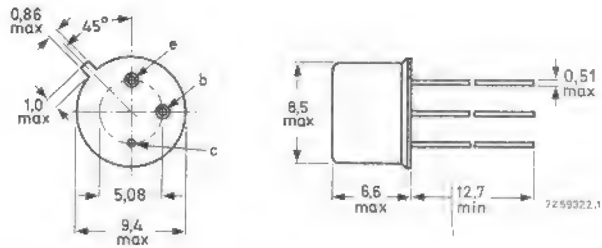
			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current (d.c.)	$-I_C$	max.	1	1	A
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1	1	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	30	
		<	150	120	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	6	V
Collector current (d.c.)	$-I_C$	max.	1		A
Base current (d.c.)	$-I_B$	max.	0,5		A
Total power dissipation up to $T_{case} = 25\ ^oC$	P_{tot}	max.	10		W
Total power dissipation up to $T_{amb} = 50\ ^oC$	P_{tot}	max.	1		W

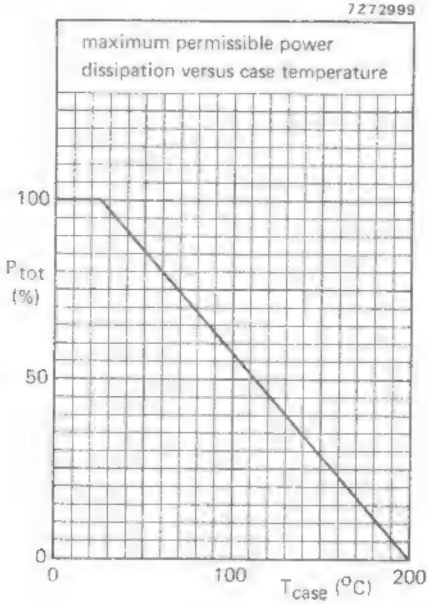


Fig. 2.

Storage temperature	T_{stg}		−65 to + 200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	17,5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	150	K/W

CHARACTERISTICS

T_{case} = 25 °C

			2N5415	2N5416	
Collector cut-off currents					
$I_E = 0$; $-V_{CB} = 175$ V	$-I_{CBO}$	<	50	–	μA
$I_E = 0$; $-V_{CB} = 280$ V	$-I_{CBO}$	<	–	50	μA
$I_B = 0$; $-V_{CE} = 150$ V	$-I_{CEO}$	<	50	–	μA
$I_B = 0$; $-V_{CE} = 250$ V	$-I_{CEO}$	<	–	50	μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	20	–	μA
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<	–	20	μA
Sustaining voltage					
$I_B = 0$; $-I_C = 0$ to 50 mA	$-V_{CEOsust}$	>	200	300	V*

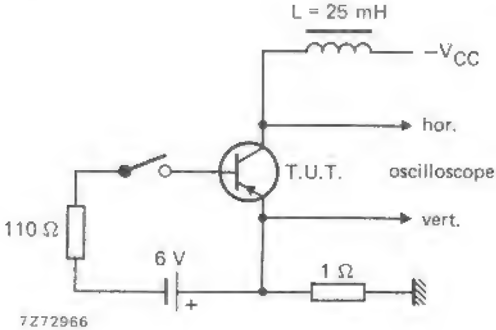


Fig. 3 Test circuit for $V_{CEOsust}$.

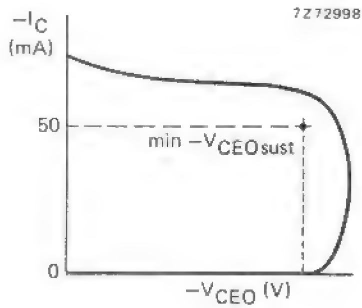


Fig. 4 Oscilloscope display for $V_{CEOsust}$.

			2N5415	2N5416	
Saturation voltages					
$-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	2,5	2,0	V
	$-V_{BEsat}$	<	1,5	1,5	V
D.C. current gain					
$-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	30	
		<	150	120	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	15		pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = -V_{EBOmax}$	C_e	<	75		pF

* Measured under pulse conditions to avoid excessive dissipation.

CHARACTERISTICS (continued) $T_{case} = 25\ ^oC$

Transition frequency at f = 5 MHz

$-I_C = 10$ mA; $-V_{CE} = 10$ V	f_T	>	15 MHz

h-parameters (common emitter)

$-I_C = 5$ mA; $-V_{CE} = 10$ V

real part of input impedance at f = 1 MHz	$R_e(h_{ie})$	<	300 Ω
small-signal current gain at f = 1 kHz	h_{fe}	>	25

SILICON N-P-N HIGH-VOLTAGE TRANSISTORS

N-P-N high-voltage small-signal transistors for general purposes and especially telephony applications and encapsulated in a TO-92 envelope.

P-N-P complements are 2N5400 and 2N5401.

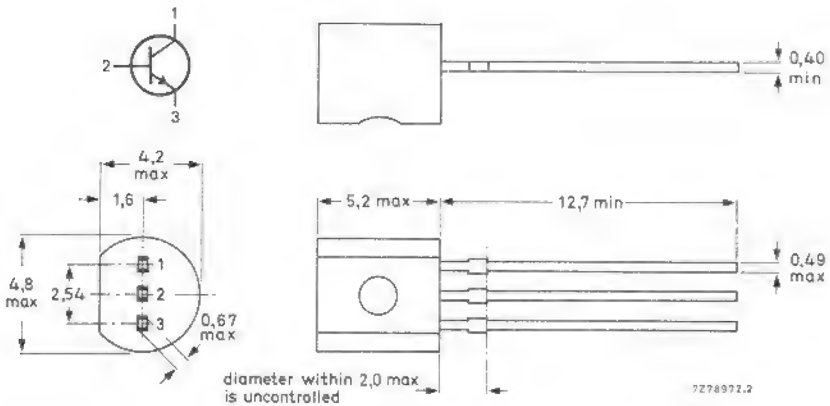
QUICK REFERENCE DATA

			2N5550	2N5551	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	180	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	160	V
Collector current	I_C	max.	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,25	0,20	V
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N5550	2N5551	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	180	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	160	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6		V
Collector current	I_C	max.	600		mA
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
up to T_{case} = 25 °C	P_{tot}	max.	1000		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		–65 to + 150		°C

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N5550	2N5551	
Collector cut-off current					
$I_E = 0$; V_{CB} = 100 V	I_{CBO}	max.	100		nA
$I_E = 0$; V_{CB} = 120 V	I_{CBO}	max.		50	nA
$I_E = 0$; V_{CB} = 100 V; T_{amb} = 100 °C	I_{CBO}	max.	100		µA
$I_E = 0$; V_{CB} = 120 V; T_{amb} = 100 °C	I_{CBO}	max.		50	µA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 4,0 V	I_{EBO}	max.	50	50	nA
Breakdown voltages					
I_C = 1,0 mA; $I_B = 0$	$V_{(BR)CEO}$	min.	140	160	V
I_C = 100 µA; $I_E = 0$	$V_{(BR)CBO}$	min.	160	180	V
$I_C = 0$; I_E = 10 µA	$V_{(BR)EBO}$	min.	6,0	6,0	V
Saturation voltages					
I_C = 10 mA; I_B = 1,0 mA	V_{CEsat}	max.	0,15	0,15	V
	V_{BEsat}	max.	1,0	1,0	V
I_C = 50 mA; I_B = 5,0 mA	V_{CEsat}	max.	0,25	0,20	V
	V_{BEsat}	max.	1,2	1,0	V
D.C. current gain					
I_C = 1,0 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	
		max.	250	250	
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	min.	20	30	
Small-signal current gain					
I_C = 1,0 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	min.	50	50	
		max.	200	200	
Output capacitance at f = 1 MHz					
$I_E = 0$; V_{CB} = 10 V	C_o	max.	6	6	pF
Input capacitance at f = 1 MHz					
$I_C = 0$; V_{EB} = 0,5 V	C_i	max.	30	30	pF
Transition frequency at f = 100 MHz					
I_C = 10 mA; V_{CE} = 10 V	f_T	min.	100	100	MHz
		max.	300	300	MHz
Noise figure at R_S = 1 kΩ					
I_C = 250 µA; V_{CE} = 5 V; f = 10 Hz to 15,7 kHz	F	max.	10	8	dB

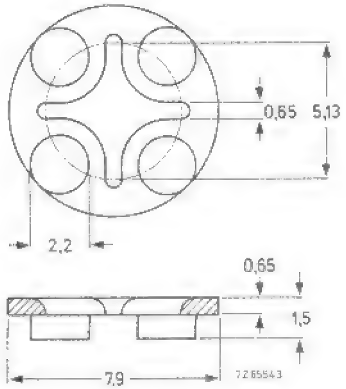
DISTANCE DISCS

MECHANICAL DATA

Dimensions in mm

Fig. 1 **56245** for **TO-5** or **TO-39**.

Insulating material.

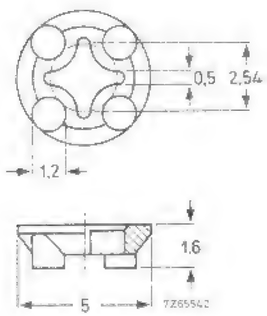


TEMPERATURE

Maximum permissible temperature T max. 100 °C

Fig. 2 **56246** for **TO-18** or **TO-72**.

Insulating material.



TEMPERATURE

Maximum permissible temperature T max. 100 °C

INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

type no.	book	section	type no.	book	section	type no.	book	section
BA220	S1	SD	BAS29	S7/S1	Mm/SD	BAV101	S7/S1	Mm/SD
BA221	S1	SD	BAS31	S7/S1	Mm/SD	BAV102	S7/S1	Mm/SD
BA223	S1	T	BAS32	S7/S1	Mm/SD	BAV103	S7/S1	Mm/SD
BA281	S1	SD	BAS35	S7/S1	Mm/SD	BAW56	S7/S1	Mm/SD
BA314	S1	Vrg	BAS45	S1	SD	BAW62	S1	SD
BA315	S1	Vrg	BAS56	S1	SD	BAX12	S1	SD
BA316	S1	SD	BAT17	S7/S1	Mm/T	BAX14	S1	SD
BA317	S1	SD	BAT18	S7/S1	Mm/T	BAX18	S1	SD
BA318	S1	SD	BAT54	S1	SD	BAY80	S1	SD
BA423	S1	T	BAT74	S1	SD	BB112	S1	T
BA480	S1	T	BAT81	S1	T	BB119	S1	T
BA481	S1	T	BAT82	S1	T	BB130	S1	T
BA482	S1	T	BAT83	S1	T	BB204B	S1	T
BA483	S1	T	BAT85	S1	T	BB204G	S1	T
BA484	S1	T	BAT86	S1	T	BB212	S1	T
BA682	S1	T	BAV10	S1	SD	BB405B	S1	T
BA683	S1	T	BAV18	S1	SD	BB417	S1	T
BAS11	S1	SD	BAV19	S1	SD	BB809	S1	T
BAS15	S1	SD	BAV20	S1	SD	BB909A	S1	T
BAS16	S7/S1	Mm/SD	BAV21	S1	SD	BB909B	S1	T
BAS17	S7/S1	Mm/Vrg	BAV23	S7/S1	Mm/SD	BBY31	S7/S1	Mm/T
BAS19	S7/S1	Mm/SD	BAV45	S1	Sp	BBY40	S7/S1	Mm/T
BAS20	S7/S1	Mm/SD	BAV70	S7/S1	Mm/SD	BC107	S3	Sm
BAS21	S7/S1	Mm/SD	BAV99	S7/S1	Mm/SD	BC108	S3	Sm
BAS28	S7/S1	Mm/SD	BAV100	S7/S1	Mm/SD	BC109	S3	Sm

Mm = Microminiature semiconductors for hybrid circuits
SD = Small-signal diodes
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes
Sm = Small-signal transistors

* = series
FET = Field-effect transistors
Mm = Microminiature semicondcutors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

P = Low-frequency power transistors

P = Low-frequency power transistors

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
WBT = Wideband hybrid IC transistors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
RT = Tripler
Sm = Small-signal transistors
ThM = Thyristor modules
WBM = Wideband hybrid IC modules
WBT = Wideband hybrid IC transistors

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
PDT = Photodiodes or transistors
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
Th = Thyristors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
Th = Thyristors
Tri = Triacs

* = series
PM = Power MOS transistors
R = Rectifier diodes
SP = Low-frequency switching power transistors

* = series
D = Displays
Mm = Microminiature semiconductors for hybrid circuits
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

I = Infrared devices
LED = Light-emitting diodes
P = Low-frequency power transistors
Ph = Photoconductive devices
R = Rectifier diodes
Sm = Small-signal transistors
St = Rectifier stacks
WBM = Wideband hybrid IC modules

A = Accessories
FET = Field-effect transistors
I = Infrared devices
Ph = Photoconductive devices
R = Rectifier diodes
RFP = R.F. power transistors and modules
SD = Small-signal diodes
SM = Small-signal transistors
Vrf = Voltage reference diodes
WBT = Wideband hybrid IC transistors

A = Accessories.

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